Volume 18 Number 3

BULLETIN
of the
AMERICAN ASSOCIATION OF
PETROLEUM GEOLOGISTS

MARCH 1934

NATURAL GAS AND OIL IN INDIA[1]

D. DALE CONDIT[2]
West Los Angeles, California

ABSTRACT

Geological evidence warrants the conclusion that commercial amounts of gas are to be found in numerous places in Baluchistan, the Punjab, Assam, and Bengal. Substantial amounts have been encountered in some of the wells drilled in search of oil, but no attempt has been made to utilize this gas, with the exception of small amounts utilized in some of the oil fields.

The oldest strata showing direct manifestations of oil and gas are of Upper Cretaceous age. Oil seepages have been noted in these and immediately overlying strata in Baluchistan and Northwest Frontier Province, and small quantities of oil have been produced from wells drilled into Cretaceous beds at Khattan in the Bugti Hills and from pits dug at Moghul Kot. In parts of Baluchistan, where seepages have been noted, the Upper Cretaceous strata consist of dark, *Foraminifera*-bearing shales, dark shaly limestones, and interbedded sandy shales and sandstones.

Elsewhere, not only in Baluchistan but also in all the potential oil and gas regions of India, the great objective horizons lie in rocks of Tertiary age. In the Punjab and Northwest Frontier provinces, the petroliferous beds are exclusively Eocene. In Assam the principal occurrences lie in formations probably ranging from Oligocene to Miocene in age; with one possible Cretaceous occurrence. In the broad Tertiary belt southward from Assam to the Bay of Bengal seepages of gas are found in almost all exposed rocks of the geologic column from the Miocene upward, but with very few showings of oil. Farther south in the same belt along the Arakan coast of Burma, oil seepages are plentiful in strata probably of Miocene age.

INTRODUCTION

This paper, dealing with parts of India other than Burma, supplements one by Dudley Stamp on Burma (p. 315). Although the subject specified is "gas," this discussion deals with both oil and gas, since the two are commonly in close association under similar geologic conditions. The information set forth, though taken largely from pub-

[1] Manuscript received, September 24, 1932, for the Association's symposium on the natural gas resources of the world—a volume whose scope was subsequently restricted to North America. The author of the manuscript on India has given permission for its publication in the *Bulletin*.

[2] Consulting geologist, 11,140 Montana Avenue.

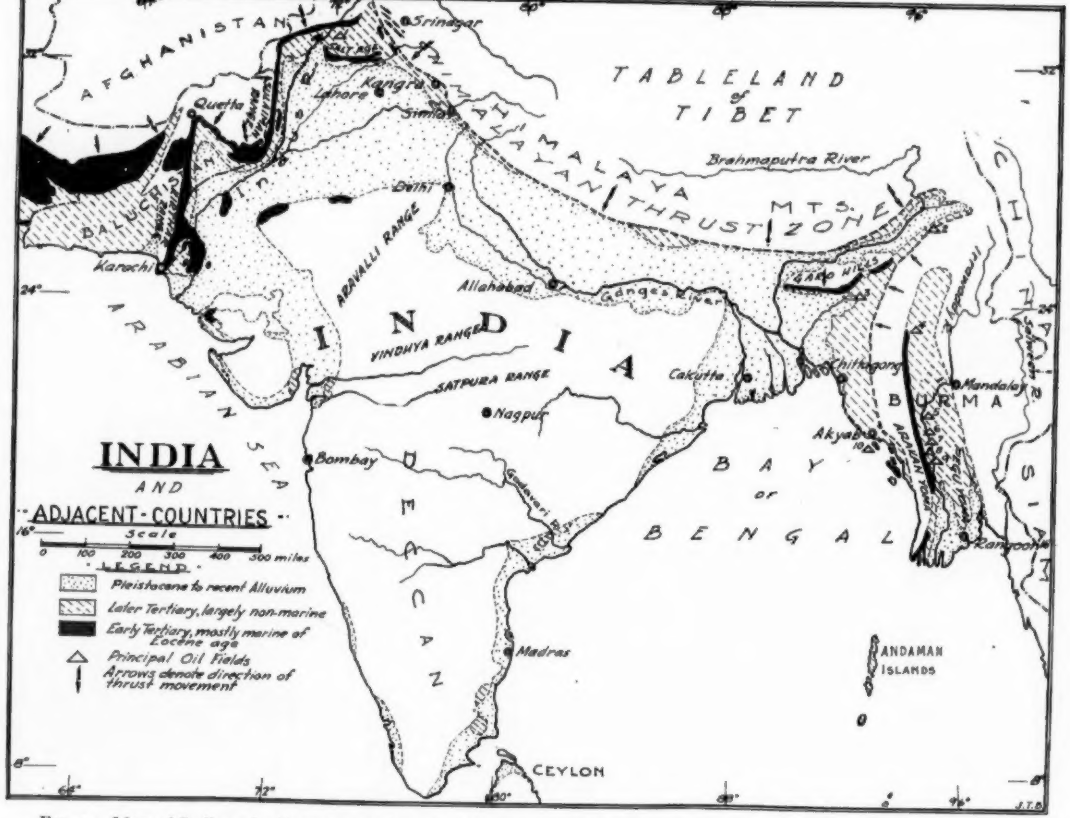


FIG. 1.—Map of India and adjacent countries; oil fields represented by triangles as follows: (1) Khaur field (Attock Oil Company), Punjab, (2) Digboi field (Burmah Oil Company), upper Assam, (3) Badarpur field (Burmah Oil Company), lower Assam, (4) Indaw, upper Burma, (5) Yenangyat-Singu, (6) Yenangyaung, (7) Minbu, (8) Yenanma, (9) Padaukpin, (10) Arakan (on Arakan Coast of Burma).

lished reports of the Geological Survey of India, draws also on unpublished data obtained by the writer and associates from 1919 to 1927 while in the employ of the Whitehall Petroleum Corporation, Limited, London.

Springs with bubblings of gas and related phenomena are widely distributed in India and, from time immemorial, have attracted the attention of the people, who have regarded them with mixed fear and reverence. Notable instances are those of Kangra, in the Punjab, and Sitakund, in eastern Bengal, where temples have been built over the seepages because the Hindus believe these to be a manifestation of the goddess Devi. Spectacular eruptions in the form of mud volcanoes are prevalent in the coastal region of southern Baluchistan and on the sea bottom adjacent to the Arakan coast of Burma. Slightly saline springs, together with occasional bubblings of inflammable gas and oil, seen in the jungle regions of Assam and eastern Bengal, are of more or less geological significance. Such places are favorite haunts of elephants and other animals and are known as "pungs." Seepages of gas under less conspicuous circumstances are plentiful in many parts of India. The various modes of occurrence and their geologic significance are discussed at length in the several regional memoirs by E. H. Pascoe, of the Geological Survey of India (17, 22, and 24 of bibliographical list at end of this paper).

GEOLOGICAL SETTING

The accompanying index map (Fig. 1) shows areas in India and Baluchistan occupied by formations of possible prospective value. Infolded strips of mountainous regions as well as isolated late-Tertiary basins are included, though of doubtful prospective value. The map also shows the broader geologic features, such as structure.

Topographically the surface of India is divisible into three principal provinces: (1) the great V-shaped peninsula of central and southern India, consisting largely of plateau and low mountain areas; (2) the Indus-Ganges Plain, a broad alluvial belt, mostly less than 500 feet in elevation, extending across northern India from the Arabian Sea on the southwest to the Bay of Bengal on the southeast; and (3) the border mountains forming the frontiers on the northwest, north, and northeast. The Burma basin on the east is separated from India by a north-south mountain range and in turn is bounded on the east by the mountainous Shan Plateau.

The Great Peninsula consists almost entirely of pre-Tertiary rocks, largely pre-Cambrian, with local thin veneers of late Paleozoic and Mesozoic rocks. This area has probably been a stable part of the

earth's crust since ancient time, most of which, except locally and temporarily, has not been submerged beneath the sea. Within this area, tracts of sedimentary rocks as old as Cambrian have been subjected to little structural deformation and appear, locally, as gently dipping strata where preserved in down-faulted blocks. This great triangular area forms a part of ancient Gondwana Land, a great equatorial continent believed to have been joined by land bridges with parts of Africa and Australia.[3]

On the west, northwest, north, and northeast was an extensive mediterranean sea, the Tethys, which, with intermittent interruptions here and there through emergence, occupied the extra-peninsular part of India and neighboring countries from late Paleozoic to mid-Tertiary time. Remarkably fine records of the marine Carboniferous, Permian, Triassic, and Jurassic systems are preserved in the western Himalaya with sufficient of the Cretaceous and Eocene systems to suggest that the incipient stages of mountain-making in the border regions did not begin until near the end of Cretaceous time. Eocene deposition occurred in more or less restricted embayments, as the sea withdrew from the sub-Himalayan region near the close of Eocene time. Progressive subsidence of this part continued, however, to the end of Tertiary time. During this subsidence enormous thicknesses of fluviatile sandy deposits, the Muree and Siwalik formations of northern India, were swept into the downwarped area partly from land areas on the south but chiefly from elevated areas on the north which, later, were in gradual process of uplift through tilting and faulting. The great period of deformation, with pronounced folding and thrust-faulting seen in the several oil regions, began at the close of Tertiary time.

BALUCHISTAN AND SIND

GEOGRAPHY

Sind is a province in the southwestern part of India, occupying the lower Indus Valley region, in most of which elevations are less than 300 feet. It is divided into several administrative divisions known as districts, and includes the native state, Khairpur. Sind is bordered on the west and north by Baluchistan, a hilly-to-mountainous region, divided into various independent or semi-independent tribal states, as well as districts. Mining laws are modeled on those of India.

The geology of Baluchistan and Sind has been described in reports by members of the Geological Survey of India, particularly

[3] For paleogeographic maps of Gondwana Land, as believed to have existed during Permian, Triassic, Jurassic, and Cretaceous time, see: Cyril S. Fox, "Gondwana System and Related Formations," *Memoirs Geol. Survey of India*, Vol. 58 (1930), Pl. 10.

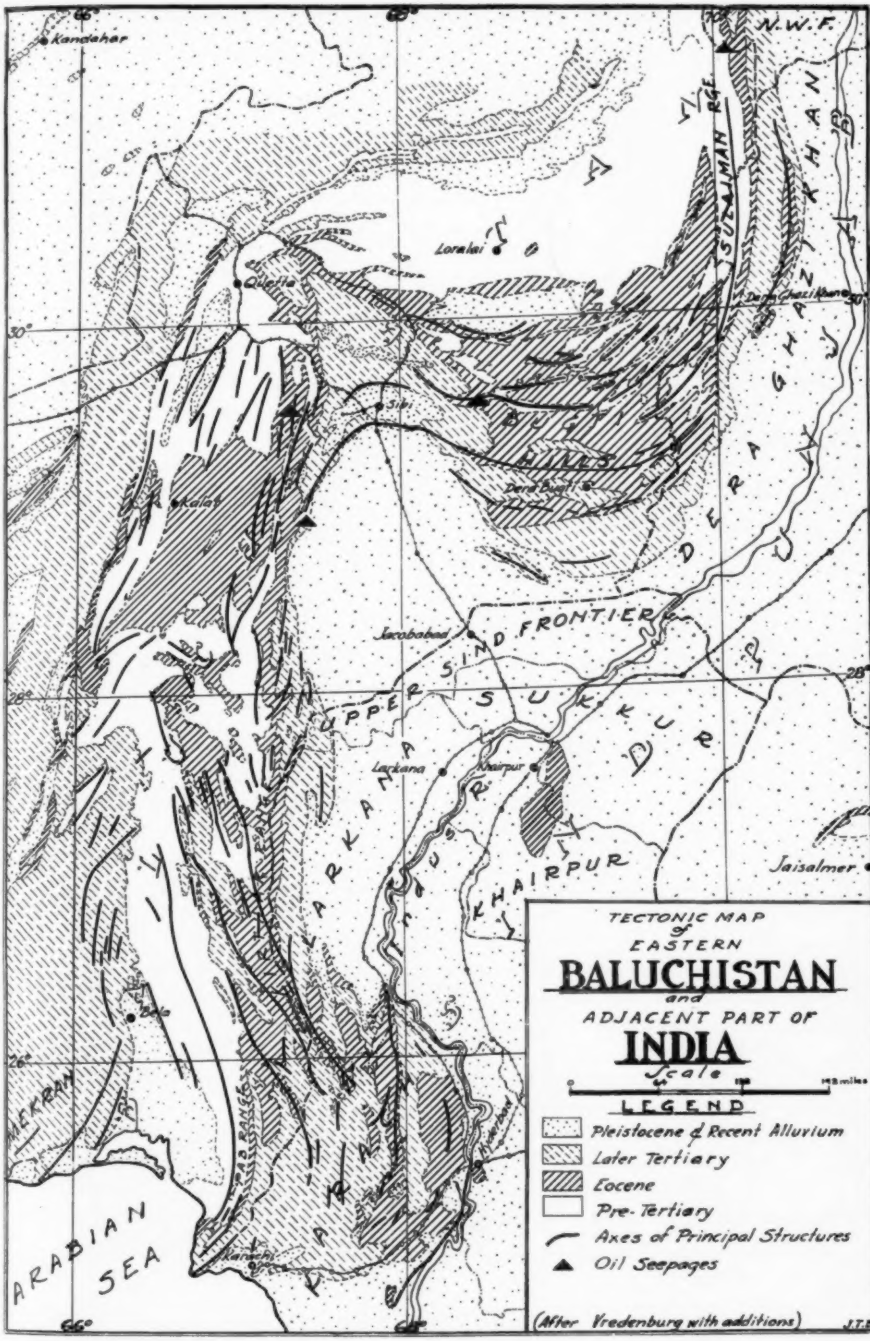


FIG. 2.—Tectonic map of eastern Baluchistan and adjacent part of India.

Vredenburg (6)[4] and Blanford (4 and 5), whose observations are incorporated in the accompanying generalized map of the eastern parts. Natural gas resources are believed to be large, particularly in the southern part adjoining the Mekran Coast, where mud volcanoes are prevalent on the crests of numerous parallel anticlines, but where no oil occurrences are known.

STRUCTURE AND STRATIGRAPHY

The structural axes are shown in Figure 2 (after Vredenburg, with modifications). The rocks composing the mountainous ranges of eastern Baluchistan consist of a great calcareous succession ranging in age from Carboniferous to Oligocene, overlain by a thick sandy series, extensively preserved in the foothills. These strata have been folded in anticlines of rounded asymmetrical profile, steepened on the east flank and locally overthrust. Successively milder folding is the rule eastward, this applying particularly to Sind, where gently arched folds of the outer front in a region of low relief are composed at the surface of Eocene strata, with no overburden of the late Tertiary fluviatile Siwalik series, although those strata appear in thicknesses of 15,000 feet or more a little farther west along the foothill belt from approximately Latitude 27° northward. Very mild folding, seen also farther north in the isolated Eocene exposures at Khairpur, further suggests that, structurally, this belt is a part of the comparatively stable Gondwana platform upon which the Eocene as well as older calcareous succession overlaps with eastward thinning. The contrasted structure here, as compared with the folded hill ranges on the west, is well described by Vredenburg, who refers to this part as the "Vorland," mostly unaffected by folding (6, Pl. 11).

In southern Baluchistan, westward from the Kirthar Range, structural trends curve from northerly to westerly directions and parallel the coast, this structural trend persisting westward to the Persian Gulf. For a distance of 150 miles northward from this coast the outcrops consist almost wholly of a thick series of post-Eocene shales and minor amounts of sandstone. These strata have been folded into a characteristic type of structure; the crests of these folds have a sharp roof-like profile as contrasted with the rounded crests of the more rigid strata in eastern Baluchistan.

Comparison of the stratigraphical record in eastern Baluchistan and the Himalayan front shows fairly close resemblances as regards the late Cretaceous and early Tertiary, and, to a less extent, the late Tertiary fluviatile deposits, an exception being the southernmost part

[4] Numbers in parentheses refer to Bibliography at end of article.

of the region, where brackish-to-marine conditions persisted much longer than in the north. For example, in the Punjab part of the ancient gulf, which presumably opened southward, there is no known record of marine conditions later than Eocene time, whereas marine intercalations in Oligocene and Miocene times appear increasingly from the Bugti Hills (Lat. 29°) southward. Structural resemblances are less pronounced, there being only moderate asymmetry as to profile with slight outward thrusting in Baluchistan, as compared with thrusting on a major scale in the Himalayan front ranges and in the Salt Range. The remarkable development of arcuate and embayed structural trends in Baluchistan presents an interesting field for study.

This discussion of stratigraphy is restricted to rocks of Cretaceous and younger age, as there is no definite evidence of oil or gas occurrences in older formations.

GENERALIZED TABLE OF FORMATIONS, EASTERN BALUCHISTAN*

Siwalik (Pliocene and Upper Miocene), 5,000–11,000 feet
Sandstones, conglomerates, and silty clays, divisible into formational units of variable persistence, on basis of lithology; most of area is designated on map as "later Tertiary"

Gaj (Miocene), 0–1,500 feet
Sandstones, shales and clays, interbedded with calcareous, marine, fossiliferous beds northward to Latitude 28°; ferruginous sandstones and conglomerates with mammalian and other bones farther northward to where these beds thin out in Bugti Hills

Nari (Oligocene), 0–5,000 feet
Sandstones and sandy shales, with calcareous marine-fossil beds in basal part; maximum thickness occurs in the Larkhana district, thin to absent in Bugti Hills, absent in Dera Ghazi Khan

Kirthar series (Middle Eocene), 3,000–4,000 feet
Nummulitic limestones and calcareous shales, more or less gypsiferous and locally bituminous; divisible into several formations of varying character and extent

Laki series (*Ghazij shales*), (Lower Eocene), 500–2,500 feet
Calcareous, foraminiferal shales with thin limestone beds, gypsiferous clay shales, local sand-shale, lignitic facies, some of which are very thick; Dunghan limestone at base 0–1,500 feet thick, which marks basal Tertiary in northern part, where it rests on shales and sandstones of Pab formation (Upper Cretaceous)

Ranikot series (lowest Eocene), 0–2,000 feet
Restricted to southernmost part. Fluviatile, carbonaceous sandstone in basal part and calcareous, fossiliferous sandstones above

Deccan Trap (Upper Cretaceous)
Basaltic flows and agglomerates present locally in southern part and presumably related to extensive basaltic intrusions and extrusions on west side of Kirthar Range

Pab sandstones and shales (Upper Cretaceous), 3,000–5,000 feet
Lower massive, clean, quartz sandstones, overlain by alternating sandstones and sandy-to-calcareous foraminiferal shales, of shallow, marine origin. These are petroliferous strata in eastern Baluchistan

Shales and limestones (Lower Cretaceous)
Light olive-to-purplish, splintery shales and porcelaneous limestones, seen only in deepest eroded parts of Sulaiman and other ranges

* The stratigraphic corrections given in the table are based, in part, on paleontological studies by W. L. F. Nuttall (12, 14).

Age of petroliferous beds.—A few further remarks are required regarding the rocks which yield oil in eastern Baluchistan. E. S. Pinfold (16) tentatively suggests that the main seepages in Baluchistan and the Punjab are from an identical horizon. In the northern part of the Punjab, the oil issues from white, chalky, gypseous limestones, the "passage" beds, lying immediately above the "Hill limestone," a massive, cherty formation with a maximum thickness of nearly 1,500 feet, and tentatively correlated by Pinfold with the Dunghan in Baluchistan.

Pascoe (17, p. 483) remarks that the vast majority of oil seepages issue from the "passage" beds, and surmises that the oil originated in the underlying nummulitic limestones. The Cretaceous system here is thin and apparently neither Pascoe nor Pinfold regards it as a source zone.

In several Baluchistan occurrences, the oil issues from the top of the Dunghan limestones, but local conditions indicate an origin in the underlying Cretaceous strata, on which the Dunghan lies unconformably. At Khattan and Gokurth the faulted condition of the limestones may facilitate vertical migration. Five miles east from the seepage on the north flank of Khattan anticline at Des Valley, in a deeply eroded amphitheater, beds stratigraphically 2,000 feet below the Dunghan limestone are exposed. The limestone is locally less than 100 feet thick and underlying strata consist largely of dark shale together with impure, fossiliferous limestones, clay shales, and a few sandstones. Fossils from horizons ranging from 400 to 1,000 feet below the Dunghan include orbitoid *Foraminifera*, a form of Upper Cretaceous age according to T. Wayland Vaughan.[5]

Pitch exudations were found in these same beds, and ether cuts were obtained from strata approximately 2,000 feet below the base of the Dunghan limestone. This evidence supports strongly the idea of an origin in Cretaceous rather than younger strata.[6]

Stratigraphy of southern Baluchistan.—West of the Kirther limestone ranges in southern Baluchistan, is a great area which Vredenburg restricts to "one geological formation, a monotonous series of folded sandstones and shales of greenish colour" (6). Higher parts of

[5] Communicated by letter through the director, United States Geological Survey, June 20, 1922.

[6] E. S. Pinfold, of the Indo-Burma Petroleum Company, in a letter dated May 5, 1933, questions this view as follows: "I think the water table plays an important part in the occurrence of oil seepages and that the seepages at low horizons such as you mention are due to the migration of oil across porous or fissured limestone formations, to appear at the surface along an underlying shale bed. . . . I think the above is the only satisfactory explanation of seepages in Cretaceous or Jurassic rocks at Khattan, Moghul Kot and Kundal."

the section near the coast include the Hinglaj sandstones, white, friable beds, several thousand feet thick; lower parts consist largely of slightly consolidated, easily eroded, clay shales. The white sandstones are regarded as Lower Miocene in age. The scarcity of fossils has prevented age determination of the underlying shales, but Vredenburg regards them as probably the equivalent of the Gaj. Denudation has produced a peculiar topography in this region, with rugged hills of sandstone in the synclinal areas and valleys of shale along the anticlinal axes. Thicknesses, though unknown, may be great, because almost no outcrops of Eocene limestone have been noted in a broad belt 150 miles in width from north to south which extends westward a distance of more than 500 miles into Persian Baluchistan, a region in which the post-Eocene formations lie in successive parallel folds with east-west trends.

SEARCH FOR OIL AND GAS

The several oil seepages in northeastern Baluchistan have been known since 1880. These and near-by localities were described at approximately that time by Oldham and other members of the Geological Survey of India (10). Ideas concerning conditions governing the mode of occurrence have changed greatly since that time and the reports are, in certain respects, obsolete. Early development was confined to shallow wells located near seepages where conditions are, for one reason or another, unfavorable for the presence of large accumulations. A few geologically located wells have been drilled in late years without success, though, in nearly every case, such wells have been drilled to objectives in the basal Eocene or Upper Cretaceous.

CONDENSED SUMMARY OF OIL OCCURRENCES

Moghul Kot

Active seepages of light oil on east slope of Sulaiman Range in Northwest Frontier Province a few miles outside border of northeastern Baluchistan; local geology described by La Touche (8) and others. Oil issues from lower part of eastward dipping sandstone forming east flank of anticlinal mountain range; age of beds probably Pab formation. Oil has been derived in small way from pits dug in river bed

Khattan

Seepages of dark oil, heavy as water, rise in springs on fault-shattered, plunging nose of large mountainous anticline, faced with dip slopes of Dunghan limestone. One or more ravines on higher part of structure cut through oil horizon, which is seen to consist of calcareous sandstones interbedded with dark, richly bituminous, fossiliferous shales, lying 400 feet or more below base of Dunghan limestone. Fossil determinations indicate Upper Cretaceous age. About 50 years ago Public Works Department drilled group of wells to depths of 500 feet or less near seepages from which total daily production of several hundred barrels of oil was obtained for short period. For description of activities see Townshend (9)

Gokurth

Seepage of heavy, dark oil rising in spring near fault on northward plunging anticlinal ridge of Dunghan limestone; situation 25 miles westward from Sibi in Bolan

Pass region. Drilling on near-by anticline where seepage horizon lies at depth of 1,000 feet has not been carried to sufficient depth for a test

Sanni—Sulphur Mines

About 45 miles southwest of Sibi, sulphur occurs as impregnation in breccia along fault of large throw, in which Nari sandstone lies against Upper Siwalik beds. In old workings, oil is reported to have dripped from roof and was collected and used for fuel in purification of sulphur, as described by Hutton (7). There is no evidence as to source, but it may have risen from considerable depths with waters of sulphurous thermal springs. Local geological details described in report by W. L. F. Nuttall.

Khairpur

La Touche states that iridescent films of oil were seen on surface of water in pit dug at Saleh Mangrio, a few miles northwest from Khairpur (11). Near-by outcrops of nummulitic limestone suggest presence of large, gently arched, anticlinal dome with Ghazij shales as lowest strata exposed. With thickness comparable with those in nearest outcrops 100 miles westward and northward in hills of Baluchistan, Upper Cretaceous sandy horizons should lie within moderate drilling depths. A few years ago a well is reported to have been drilled at location selected by Burmah Oil Company with unfavorable results. The depth is reported to have exceeded 4,000 feet and to have penetrated Mesozoic strata, as proved by fossils. Many years earlier the Government made attempt at drilling and reached depth of 1,500 feet, but location, at Sukkur, was not well placed

Karachi

B. Krookshank (15) describes well drilled to 815 feet for water near Karachi, in which oily scum was reported by engineer in charge. Weathered cores tested for oil residue months later failed to show any. Evidence appears inconclusive

Dera Ghazi Khan

Outcrops of middle part of Nummulitic series, along Zinda Pir anticline, in central part of Dera Ghazi Khan District, contain beds of gypsum and lean oil shales which, on distillation test, yield 10 gallons of oil per ton, and samples show ether cuts

So far as can be deduced from the stratigraphical and geographical distribution of oil occurrences, rocks of Upper Cretaceous and basal Eocene age offer fair prospects in the hills of northeastern Baluchistan. Still deeper horizons may warrant testing in areas of less pronounced structural deformation, but the probable eastward thinning of formations, with numerous stratigraphical breaks, may have an unfavorable bearing. Within the Eocene are localized sandy facies with lignitic shales which may contain favorable zones. In large areas of the Eocene, however, there are no known porous sandy strata to be regarded as suitable reservoir rock. Whether or not the limestones are locally of open, porous texture is unknown. Gas in commercial quantities may be anticipated in lower parts of the Siwalik where structural conditions are favorable; likewise, the Nari and Gaj formations in more southern areas, where these strata are present and well developed.

In the Mekran Coast, geological conditions are decidedly different from those in eastern Baluchistan. The broad belt of clay shales and sandstones extending westward for many hundred miles, and possibly the depositional equivalent of the Nari and Gaj, offers a great field for exploration with probability that gas can be discovered in quanti-

ty. Although no oil occurrences have been reported, strata which probably should be correlated with the Mekran beds are reported to be petroliferous adjacent to the Strait of Hormuz, 600 miles west of Karachi. The intervening region is comparatively unknown, geologically.

Observers report a prevalence of mud volcanoes in places where the anticlinal axes lie along shale valleys. The cones are commonly 100 to 300 feet high and give forth salty water, liquid mud, and inflammable gas (1, 2). A sample of gas from a locality 15 miles northeast of Ormara was analyzed by Christie (3), who found members of the paraffine series with a higher carbon content than marsh gas. His analysis follows.

ANALYSIS OF GAS FROM MUD VOLCANO NEAR ORMARA

	Per Cent		*Per Cent*
Methane	74.5	Carbon dioxide	1.4
Ethane	8.9	Oxygen	0.7
Unsaturated hydrocarbons	0.7	Nitrogen	13.8

The only locality where drilling has been attempted on the Mekran Coast is the Chandragup anticline at the mouth of Hingol River, about 50 miles east of Ormara. Efforts were carried on for several years by the Burmah Oil Company without reaching more than moderate depths, probably less than 2,500 feet.

PUNJAB AND NORTHWEST FRONTIER PROVINCE

GEOGRAPHY

Punjab Province lies northeast of Baluchistan and is bordered on the west by the Northwest Frontier Province, which adjoins Afghanistan. Northwest Frontier Province is a hilly-to-mountainous region.

The geography and the geology of this region are shown in Figure 3. Most of the Punjab except the northwest part is a featureless alluvial plain only a few hundred feet above the sea. The outermost mountains, the Salt Range, rise to average elevations of 3,000–4,000 feet, with steep south slopes and comparatively gentle north slopes which merge into a broad plateau region, ranging from 1,200 to 2,400 feet elevation, the Potwar Plateau, which structurally is a synclinorium. The successive parallel hill ranges north of the plateau, with intervening alluvial valleys, are foothills of the Himalaya, produced by folding and up-faulting which characterizes this entire front, from the Punjab eastward to upper Assam.

The Tertiary strata in northeastern Baluchistan extend northward in a narrow belt along the Sulaiman Range into the Northwest

Frontier Province, curving eastward and broadening in their extension through the northwest Punjab oil region. Oil and gas seepages are widely distributed and early led to minor development, practically all of which, as late as 1914, was without sound geologic guidance. More than 30 years earlier, excellent pioneer work had been carried on by Wynne (18), whose maps are true representations of the general geological structure. Khaur, the one producing field in the Punjab, lies along a "structure" mapped by Wynne, who failed, however, to note the presence of an oil seepage, discovery of which led to drilling

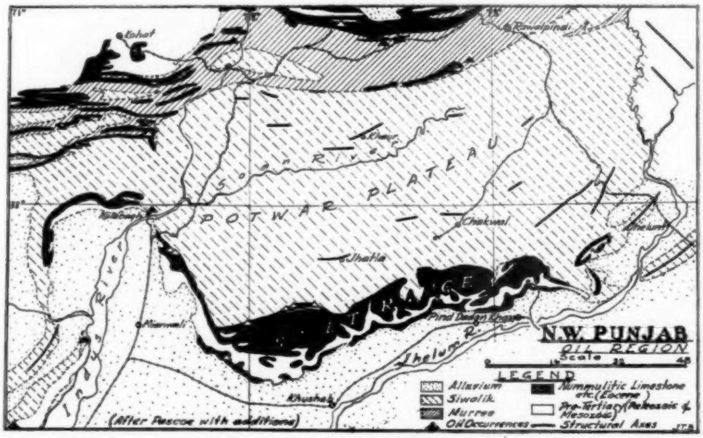


FIG. 3.—Map of northwest Punjab oil region.

in 1914. E. S. Pinfold, responsible for this discovery, has summarized the geology of the northwest Punjab oil region in a paper published in 1918 (16). Two years later an account by Pascoe, a modern and able presentation, appeared (17). Much has been published on the complicated structure of this region, some of which is based on conceptions now discarded. Robert Anderson (19) and J. M. Weller (20) give concise summaries of present views. Weller, assistant to B. R. MacKay, carried on geological investigations in this region, and Anderson reviewed certain phases of the work.

STRUCTURE AND STRATIGRAPHY

The stratigraphical column in northwest Punjab includes only a slight development of Cretaceous rocks, partly marine, a substantial thickness of Eocene rocks, largely marine, and immense thicknesses of post-Eocene fluviatile deposits, the Murree and Siwalik series.

Gradual uplift in the Himalayan region, near the close of Cretaceous time, initiated the sub-Himalayan trough, an arm of Tethys Sea extending into the Baluchistan-Sind region on the southwest, and into the Assam region on the east. In this sea were deposited basal Eocene shaly sands and overlying calcareous, nummulitic beds in thicknesses varying from a few hundred to more than 1,500 feet, with maximum thicknesses in extreme northwestern parts of the Punjab. The formation known as the "Hill limestone" consists of massive, cherty beds, parts of which are characterized by *Nummulites*. Above these were fresh-water and marine alternations in Upper Eocene time, locally 1,500 feet thick—the "Passage beds" consisting of variegated shales, nummilitic shales, and thin-bedded limestones, the youngest marine strata in the entire region. Erosion following extensive elevation and faulting removed much of the Upper Eocene deposits, especially in the areas farther south. Preservation of the thick, ferruginous "salt

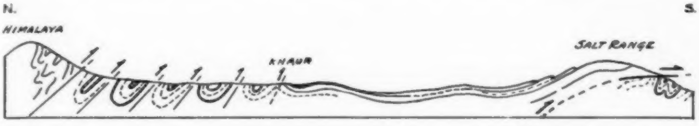


FIG. 4.—Diagrammatic cross section from Himalaya south to Salt Range, illustrating several structural zones.

marls," probably of Upper Eocene age, along the south base of the Salt Range, and beneath overthrust Paleozoic rocks, as well as in localized down-faulted blocks on the north slope of the Salt Range, leads to the inference that the regional overthrust which characterized this range began in late Eocene time.[7] At nearly this same time, elevation with possible up-faulting occurred along the Himalaya; active erosion supplied the sandy materials of the maroon Murree formation, deposited about 7,000 feet in the northern foothill region and thin to absent along the Salt Range. In later Tertiary time sedimentation was more widespread with sediments derived chiefly from the north and to a lesser extent from Gondwana Land also, the materials being composed largely of sands, and variegated silty clays and conglomerates. Thicknesses ranging from 10,000 to 15,000 feet, of these later deposits, known as the "Siwaliks," have been measured at many places. This series, mostly of continental origin, with few

[7] Some geologists still question the Eocene age of the salt beds in the Salt Range. C. S. Fox, of the Geological Survey of India, sets forth arguments in support of a pre-Cambrian age for these beds (25), thus reviving the ideas extant 30–40 years ago, when Wynne and others suggested early Paleozoic to pre-Cambrian age. Those wishing a review should read the report by Fox and the memoir by Pascoe (17, pp. 358–371).

fossils other than bones, is readily divisible into several formational units on the basis of lithology, some of which units are persistent in large areas. The great period of mountain-building with folding and faulting occurred at the close of Tertiary time when the sediment-filled trough was greatly compressed and faulted in the northern part with successively milder deformation southward. Rapid peneplanation followed. Elevation of the Salt Range produced temporary ponded conditions between it and the Himalaya. Mild deformation has persisted to the present.

Briefly the structural divisions of the region from north to south are described by B. R. MacKay as follows (Fig. 4):

(1) the great Himalayan thrust zone within which pre-Cambrian rocks are thrust-faulted against Eocene rocks, the movement being as much as 10,000 feet; also isoclinal folding; (2) the fault-fold zone, a belt co-extensive with the outcrop of the Murree formation and extending southward in the Siwalik belt as far as Khaur; this zone displays fairly broad synclines and sharp thrust-faulted overturned anticlinal rudiments, which are successively less displaced southward and only moderately at Khaur; (3) the Soan synclinorium, co-extensive with the Potwar Plateau, a broadly synclinal region with a few scattered folds in Siwalik beds; (4) the Salt Range monocline, the north slope of Salt Range composed of strata of northward dip but with local undulations; and (5) the Salt Range anticlinorium, the south flank of which is concealed and believed to have been overridden by southward thrusting of the north flank. From Indus River eastward to beyond the seventy-third meridian the range forms a single anticlinal structure, but farther east it divides into three prominent spurs: the Bakrala anticline, the Mount Tilla anticline, and the Kharian anticline.

OIL AND GAS

Petroliferous horizons.—In northern localities where the massive Eocene limestone is overlain by shaly transition beds, the oil seeps from shaly limestones a little above the top of the massive "Hill limestone." But there are exceptions where structure complicates conditions; for example, in the Khaur oil field, where oil is found in several thousand feet of Murree beds, into which it has presumably migrated by upward movement along one or more longitudinal faults which traverse the anticline. Along much of the Salt Range where the transitional shaly beds of Upper Eocene age are absent and the massive limestone is overlain directly by Siwalik sandstone, the oil commonly rises along the contact, or along beds just above the contact. Varying concentrations of dry, oily residues within laminae of cross-bedded sandstones suggest active seepages in ancient times, contemporaneous with deposition of the basal Siwalik beds. Manifestations of oil as well as gas also are noted in the salt-bearing strata along the south side of the Salt Range.

Distribution of occurrences.— The geology in the vicinity of the numerous oil seepages has been described by various observers, notably Pascoe (17). In the northern, fault-fold zone, coextensive with the outcrop of the Murree, seepages are abundant from the trans-Indus region eastward to the vicinity of Rawalpindi. Almost without exception these seepages rise from the shaly beds between the massive Eocene limestone and the top of the Eocene, the horizon being the same whether the beds lie in normal attitude or overturned. In northern localities the occurrences are usually along the lower slopes of faulted, eroded anticlines. In the Salt Range, the seepages are commonly restricted to the homoclinal zone near the contact of the Siwalik formation with the underlying massive Eocene limestone; the more profuse seepages tend to occur where the strike of the beds is curved in a broadly arcuate manner, as in the portion a little east of longitude 72°.

The easternmost seepages in the Salt Range are found at about 72° 20′ and manifestations farther east consist merely of oil-stained sands and dry oil residues along faults, together with a few showings of gas. This eastward absence of active oil seepages, considered together with a similar absence in the northern region opposite Rawalpindi, suggests that a line can be drawn in a northeasterly direction, east of which the conditions have not favored the presence of oil and its preservation. Although no oil seepages are known east of this line, there are active showings of gas at various points, for example, in the vicinity of Kangra (Longitude 76°16′).[8]

Origin of oil and gas.—Some observers, impressed with the fact that, in almost every instance, the oil rises from thin-bedded limestones and shales a little above the massive limestone, incline to the view that the oil is indigenous in these shaly strata. Others believe the massive limestones are the source, influenced perhaps by the fact that much of this limestone has a dark, bituminous appearance. Pascoe (17, p. 348) mentions the occurrence of gypsum and coal in the *Cardita beaumonti* beds at the base of the Lower Nummulitic in parts of the Salt Range and states that "oil may have been formed as early as this, though there is no definite evidence to show that it was." Elsewhere (p. 484) he states:

> It is a significant fact that when the oil horizon can be definitely recognized, it is, with the exception of Khaur, always found to belong to the Lower Chharat stage. When the latter is missing, as most of it seems to be along the northern margin of the Salt Range, the oil is found along the plane of unconformity which represents this absent stage.

[8] C. S. Middlemiss describes a dome in this region in the east, known as the Kotli dome, Punch Valley, Jammu Province, and discusses oil possibilities (21).

More recently E. Parsons has published a paper (28), dealing with the widely distributed oil occurrences and suggesting that the oil originated in basal beds of the Eocene. Apparently some of his views are not accepted by Pinfold as revealed in discussion (29).

Although the evidence for origin in Eocene strata is strong, and such as to favor its having migrated from the massive limestones of the lower portion, or perhaps from shaly to sandy strata of estuarine origin in the basal portion, there is a possibility of some oil also having been derived from still older formations. The writer surmises that the persistent localization of the oil seepages at about the same horizon may be incidental, caused by the capping of shaly limestones and clays, rather than a proof of origin in closely associated strata. Events of geologic history somewhat as follow, have a bearing on this problem.

During Jurassic, Cretaceous, and Eocene times, the orogenic history was one of intermittent slight elevation and subsidence, with shifting shore lines, but with comparatively little structural deformation. Depositional conditions favoring the accumulation of materials such as are thought of as source beds were not restricted to the Eocene. For instance, the Middle and Upper Jurassic, which are best developed in the western part, comprise calcareous marine and carbonaceous, sandy strata, locally coal-bearing. Coal, reported to be of Jurassic age, is mined at Kalabagh, in the western part of the Salt Range. Cretaceous strata, though widely distributed, are thin and consist largely of sandy, carbonaceous shaly materials so closely conformable with the Eocene beds that differentiation is difficult.

Structural deformation previous to the close of the Eocene was too slight to favor upward migration of hydrocarbons into zones substantially younger than those in which they originated. At the close of Eocene time, however, mountain-making processes with uplift, folding, and local faulting, set in, to a moderate degree, in the Himalayan region and in the Salt Range region and were repeated intermittently to the end of Tertiary time when major diastrophic events occurred. Ample evidence of the late Eocene deformation is found along the Salt Range, consisting of warping, faulting, and subsequent erosion previous to Siwalik deposition. It is believed that this late Eocene deformation permitted upward migration; seepages of oil probably became active along the eroded surface contemporaneous with deposition of the sandy materials of the basal Siwalik. More extreme diastrophic processes coming at the end of the Tertiary induced lateral migrational adjustments during which appreciable amounts of oil and gas also found their way upward into the Siwalik (or Murree where present), much of which have been lost subsequent-

ly by active artesian circulation. Locally along the monoclinal front of the Salt Range viscous residues are seen along joint planes, bedding planes, and within the layers of sandstones several hundred feet above the base of the Siwalik.

Khaur field.—Development of this field, situated about 40 miles southwest from Rawalpindi, was started about 1914 by the Attock Oil Company. After about 10 years, when sufficient production had been obtained to warrant a refinery, one was constructed at Rawalpindi, with a pipe line to the field. In 1929, the production was 480,222 barrels, with similarly substantial amounts in the years immediately preceding. In 1930, the amount fell off by about 60 per cent to 191,249 barrels, due, according to the director of the Geological Survey of India (23), partly to failure to find new oil-producing zones above 4,200 feet, and partly to the fact that none of the five wells still drilling to the 4,600- and 4,800-foot zones had reached its objective, because high gas pressures retarded drilling. In 1931, the production fell further, to 138,806 barrels. Two tests had been drilled to depths below 5,000 feet, one in the western portion being 5,670 feet. No promising sands had been encountered below the 4,800-foot zone.

Structure of the Khaur field is an asymmetric fold of east-west trend, with dips of about 45° on the north flank and 25° to 35° on the south flank. The axial part is cut by one or more high-angle faults of easterly trend with the south side down; this locality is situated in the outer part of the fault-fold zone of the Himalayan foothills. The oil is obtained from numerous sands in the Murree formation found at various depths and it is probable that the oil moved upward into these faulted strata from the Eocene zone, which, so far as known, has not been reached in wells. Geological conditions are set forth by Pascoe (17).

Significant test wells elsewhere. Dhulian.—A few miles southwest of the Khaur structure and separated from it by a structural saddle is the Dhulian structure, a more open, attractive appearing, elongated dome with comparatively little faulting. Drilling will be deep here, not only because the surface rocks are substantially younger than at Khaur, but also because it is probable that vertical migration of the oil has been much less than at Khaur. Development has been retarded by high-pressure water sands, and productive horizons have not been encountered down to a depth of 3,300 feet.

Kharpa.—Sixteen miles west of Khaur is a faulted, compressed anticline which was drilled by the Burmah Oil Company several years ago without reaching the oil-bearing zones.

Jhatla.—Thirty-two miles southward from Khaur, near the homoclinal zone of the Salt Range, is a large, gently arched, elongated dome which was tested by the Whitehall Petroleum Corporation, Ltd., in 1925. Drilling started in Middle Siwalik beds and the Nummulitic limestone was reached at a depth of 5,925 feet without encountering more than traces of oil or inflammable gas. Development and geological conditions are set forth by Robert Anderson (19).

Ghabir River.—About 15 miles southwest from Jhatla, on the slopes of the Salt Range, are numerous oil seepages issuing along the contact of Eocene beds with the Siwalik. Here there is a slight northward bow in the monoclinal structure with northward dips of 12°–25°. The Indo-Burma Petroleum Company drilled a test well at a point slightly down dip from the seepages, without favorable results.

Further possibilities.—In both the Northwest Frontier Province and the Punjab are structures of possible value which have not been drilled. Some are of doubtful promise because of compressed folding and faulting, or because they are too deeply eroded; others, though attractive structurally, lack attraction for certain other reasons. Some of the deeply buried structures adjacent to the eastern part of the Salt Range seem to offer promise of gas, but less promise of oil for the reason that they lie outside of the area of oil seepages. The unfavorable results at Jhatla do not necessarily condemn possibilities on other structures adjacent to parts of the Salt Range farther east, because the absence of oil and gas at Jhatla may be due to lack of sufficient structural closure on deep horizons, although the surface rocks are folded into a domal structure with moderate structural closure.

ASSAM PROVINCE

GEOGRAPHY

Assam Province lies in the extreme northeastern part of India. On the north are the Himalaya rising abruptly from the lowlands of the Brahmaputra Valley, and on the southeast, the Naga Hills and other mountainous ranges, beyond which lies the basin of Burma. Southward the Naga Hills merge into the Lushai Hills and the several ranges of Tripura State, which in their more southerly extension are known as the Arakan Yoma. In central Assam is an east-west trending mountain group, the Garo, Khasi, Jaintia and Mikir Hills, surrounded on almost all sides by alluvial plains of the Ganges and Brahmaputra river systems.

The literature is scant and restricted chiefly to brief accounts of journeys along some of the routes of travel, together with reports

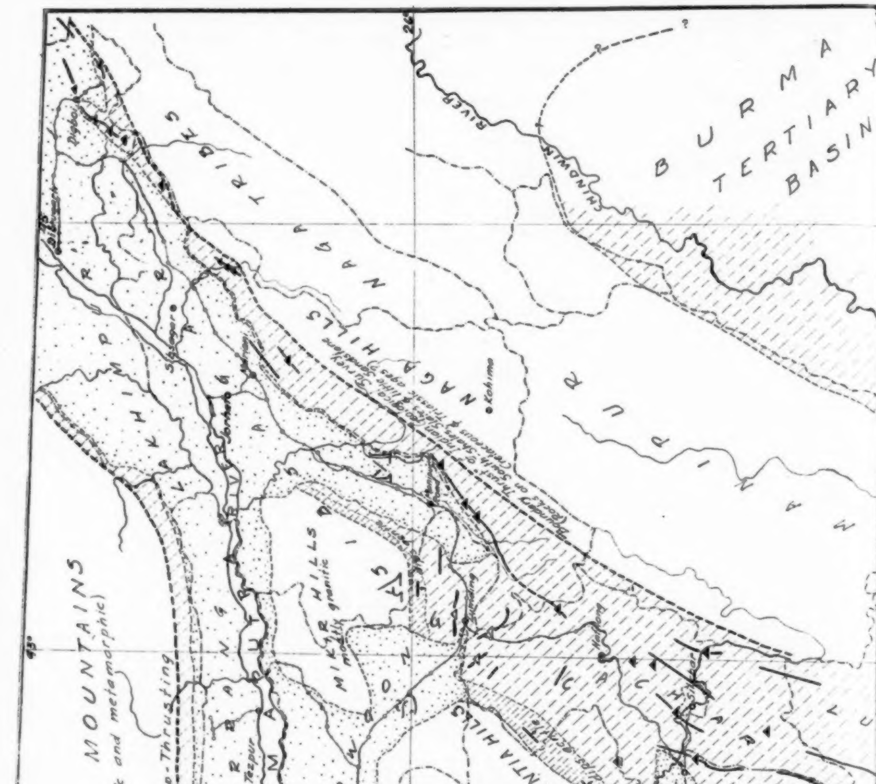
on certain coal and oil occurrences. The memoir by Pascoe, published in 1914 (22), is a short description of observations by himself and earlier workers. The accompanying map (Fig. 5) is based on the map in his report, with modifications.

STRUCTURE AND STRATIGRAPHY

Assam, from north to south, is divisible into several structural as well as geographic divisions, as follows: (1) the Himalayan front, a complex fault zone with Paleozoic and pre-Cambrian rocks upthrust against faulted and tightly compressed Tertiary strata, the Tipam series of Pascoe, comparable with the Siwaliks of the Punjab; (2) the alluvial belt of Brahmaputra Valley, 20 to 50 miles wide and widest in the northeastern part; elevations approximately 500 feet; (3) the east-west trending Garo-Mikir range, of which the western part is a dissected plateau spoken of as the Shillong Plateau; an alluvial gap separates this portion from the Mikir Hills; summit elevations range from 5,000 to 6,000 feet; the rocks are largely granitic gneiss overlapped in the southwest part by Cretaceous strata; (4) a homoclinal belt of southerly dipping Cretaceous and Tertiary strata along the south side of these hills; steep dips in the western part and gentler eastward; local undulations as well as faulting; (5) a synclinorial belt which terminates on the southeast in one or more zones of high-angle thrust faulting toward the northwest (the "boundary thrust" of Pascoe), in front of which are asymmetrical variably compressed folds with steepened north flanks and more or less faulting; (6) the Disang series, a broad belt composing all of the ranges southeastward to the Burma basin; dark shales, sandstones, slates, and phyllites, with intrusions of peridotite in the southeastern part; structurally anticlinorial; largely unexplored.

During Cretaceous and early Eocene times the shore of Tethys Sea, so far as the peninsular portion of India was concerned, followed a line much the same as the present east coast. It extended eastward through the Garo Hills, the Mikir Hills region, and thence northeastward into the upper Burma region with no certainty of a land barrier between Assam and Burma until somewhat later. Parts of the early Cretaceous surface are well preserved in the Shillong Plateau region, where marine Cretaceous strata lie on a gently sloping floor of crystalline and older sedimentary rocks. Eastward along the Mikir Hills front these Cretaceous strata are overlapped by the Eocene limestones.

Eocene to late Pliocene time appears to have been a period of deposition in a narrowing embayment with conditions varying from


HIMALAYA MOUNTAINS
(Largely granitic and metamorphic)
zone of up-Thrusting
BURMA TERTIARY BASIN
NAGA HILLS
MIKIR HILLS
mostly granitic
KHASI HILLS
Shillong
Largely Granitic & Metamorphic and with Cretaceous on south slopes
JAINTIA HILLS
GARO HILLS
KAMRUP
Tezpur
Kohima

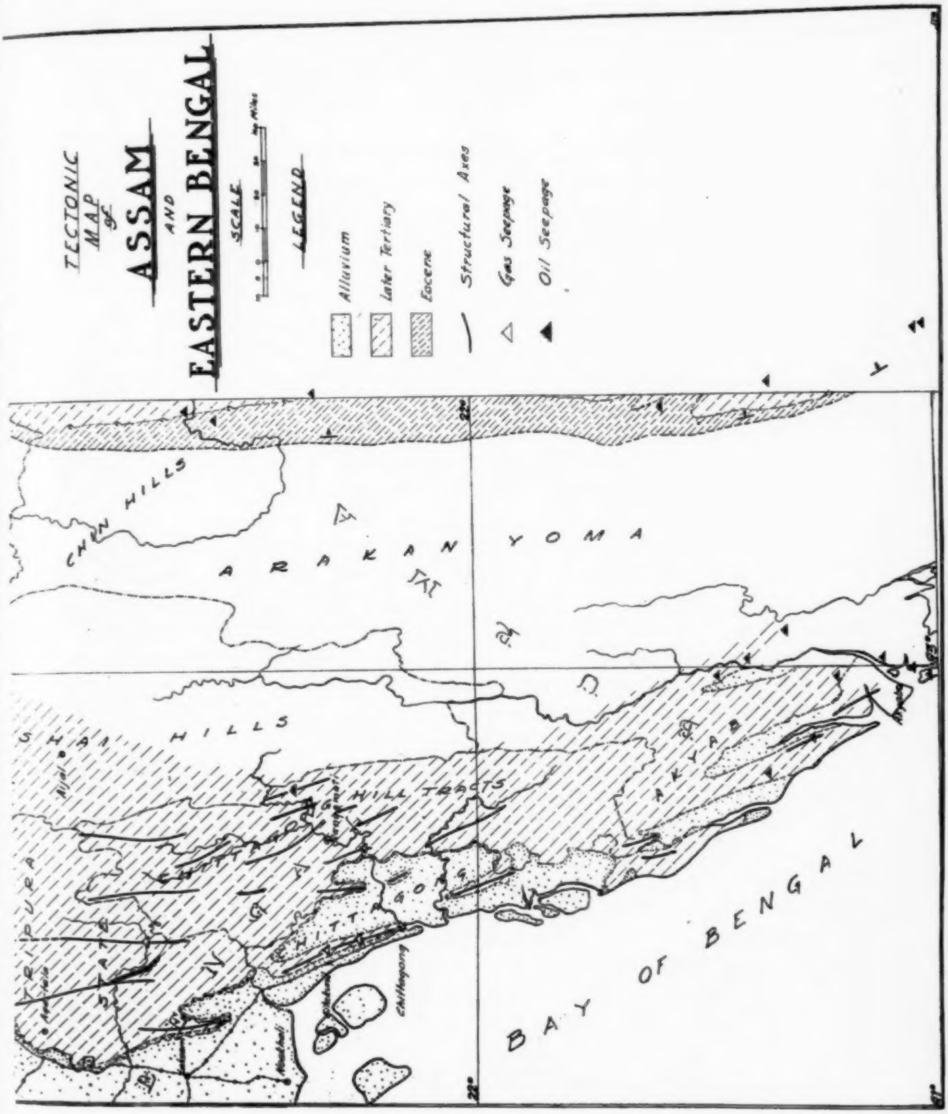


Fig. 4.—Tectonic map of Assam and eastern Bengal.

estuarine to fluviatile. Sedimentation, with down-warping toward the southeast, led to accumulations exceeding 15,000 feet in thickness in central Assam and as thick as 20,000 feet in the southern portion. Moderate elevation in the region on the north probably occurred at the close of Eocene time.

The great mountain-making periods, including the uplift of the Himalaya, came much later in conjunction with similar events in the Punjab. The Assam basin of deposition, already trough-like in profile, with a land barrier on the southeast separating it from the Burma basin, now assumed the form of a geosyncline with gently homoclinal dips in the northwest portion, where the rigid granite floor lay at shallow depths, and with mild undulatory folding toward the southeast, succeeded by sharper folding, asymmetric in profile, with overturning toward the northwest. Deposition persisted in the synclinal basins until comparatively recent times with probable localized pounding of drainage lines brought about by progressive folding and faulting. The latest deposits show only slight deformation and lie discordantly on all older formations. Structural trends show a gradual change from northeasterly to southwesterly in upper Assam, and to southerly in lower Assam, this being applicable to the folding of the southeast side adjacent to the boundary fault zone. Opposing trends occur, however, in the region 5 to 15 miles northward and northeastward from Silchar, lower Assam, where the steeply dipping beds of the east-west Khasi Hills front suddenly bend northeastward and flatten to gentle slopes, such as seen along the Jaintia and Mikir Hills. Immediately south of and opposite this bend the structure assumes a highly complicated character with probable faulting.

It is surmised that the elevation of the Garo-Mikir Hills range was one of the later events in the mountain-building period and that it may have taken place after the northeasterly trending folds were well advanced. This is suggested not only by immature topography but also by details of structure opposite the Jaintia Hills, where the east-west trends encounter those of northeasterly trend. Possible thrusting from the north may explain the complicated structure in the northern part of Surma Valley a few miles north of Badarpur, with faulting of this type grading westward into the zone of steep south dips characteristic of the south side of the Garo and Khasi Hills.

LIST OF FORMATIONS ACCORDING TO PASCOE (22)

Alluvium (Recent)
Older Alluvium (? Pleistocene)
Tipam Sandstone and Dihing Beds (probably Pliocene)
Sandstone, massive, ferruginous, also silty clays, shales and conglomerates; prob-

ably mostly fluviatile; characterized by local abundance of lignitized and silicified wood. Formation is regarded as comparable with Irrawadian of Burma.

"Coal Measures" (Miocene or Miocene and Oligocene)
Alternating shales, sandstones and coal, with a few calcareous layers; comparable with Pegu series of Burma but containing few fossils other than plant impressions
Oil-bearing series of Assam

"Nummulitics" (Eocene)
Nummulitic limestone occurring along south side of Caro-Mikir Hills, locally coal bearing

Disang series (age unknown but probably including some Cretaceous and possibly some Eocene)
Monotonous series of shales, slates, and phyllites, some hard sandstones, composing mountain ranges of Assam-Burma frontier over a width of 50–60 miles; serpentine intrusions on eastern border

The foregoing generalized table of formations by Pascoe is amplified in his memoir with details of local stratigraphy in areas studied by him. Rather than follow his classification, the writer prefers to set forth observations based on regional studies in middle and lower Assam by himself and associates, including W. J. Wright, L. G. Weeks and F. B. Notestein.

Stratigraphy in central Assam adjacent to Mikir Hills region.—The granitic Mikir Hills are bordered on the south by gently dipping nummulitic limestones which are more or less sandy and thinner than along the outcrop on the southwest. These beds are overlain conformably by thin-bedded sandstones, sandy shales, and carbonaceous shales, with some calcareous, fossiliferous layers here and there, the aggregate thickness probably ranging from 1,200 to 1,800 feet. These strata probably are in part equivalent to the "Coal Measures" of upper Assam. The next higher formation is massive sandstone, thick-bedded and medium- to fine-grained, with occasional shaly members which commonly are carbonaceous. The full thickness of the formation is not evident along this front because it, as well as all older formations, is overlain unconformably, and irregularly overlapped, by silty shales of a much younger formation which, with a still higher "fossil wood" ferruginous sandstone formation, occupy synclinal areas here and eastward. Southwest from here, however, in the hills of north Cachar District, are complete exposures in a broad belt 10 to 20 miles wide, with thicknesses of 5,000 feet and more. This sandstone formation composes the irregular-shaped, Hatikhali anticline a few miles south of Lumding Junction, and the name Hatikhali sandstone has been applied to it. It is seen in numerous cuts along the railway southward from Lumding for a distance of about 28 miles to the vicinity of Mupa Station, where the railway crosses onto overlying shales in a broad synclinal belt southeast of which is a faulted anticlinal ridge along which sandstones of older formations again appear.

Details along Naga Hills.—These hills border the central and upper Assam valley on the southeast, rising more or less abruptly to elevations of 2,000 feet or more, in successive southeastward dipping strike ridges of sandstone. The outer ranges constitute a structural and stratigraphical unit from the hill section of the Assam-Bengal Railway in Cachar District northeastward for more than 200 miles. Along them are a number of overturned anticlinal folds, some of which are petroliferous.

The principal rivers draining the mountainous areas on the southeast flow northwestward across the Naga Hills and their gorges reveal splendid exposures of the rocks. Typical profiles show complicated anticlinal structure along or near the outer margin of the hills, with steep dips and overturning toward the northwest, and local thrusting. Southeast flanks with comparatively gentle and regular dips are characteristic, with successive hogback ridges formed by the more resistant strata, and with successively lower ridges on the southeast in less resistant strata composing higher parts of the section. Several miles southeastward from the outer anticlinal margin, older strata again rise along discontinuous lines of uplift, some of which are more or less regularly anticlinal with little faulting, while others are faulted. While Pascoe and other observers picture a "Boundary thrust" as sharply limiting this belt of Tertiary strata on the southeast, it seems more probable that there are successive lines of thrusting with lower and lower horizons exposed in each, and that the entire belt of Tertiary strata in the Naga Hills lies within this broad zone of combined folding and northwestward thrusting.

GENERALIZED STRATIGRAPHIC COLUMN, IN DESCENDING ORDER, BASED ON OBSERVATIONS ALONG DISAI, DOIANG, ZUBZA, DIPHU, AND DHANSIRI RIVERS

Disai series (probably equivalent in part to "Fossil Wood group" of Pascoe), 8,000–12,000 feet or more. Slightly consolidated sands, silts, and variegated clays, lying in approximate parallelism on Chimakudi sandstones, but with higher portions overlapping upturned edges of older strata. Characterized by abundance of woody material, some of which is carbonized or silicified and some only slightly lignitized. Occupies synclinal troughs throughout area with maximum thicknesses in intermontane valleys such as those cut across by Disai, Diphu, and other rivers, where entire sequence is commonly tilted to dips of 45° to 60°

Chimakudi sandstones (named from village of that name near Diphu River), 2,000–3,000 feet. Massive to thin-bedded sandstones, with interbedded shale members; rich in hornblende, epidote, kyanite and other minerals, as reported by V. C. Illing; probably fluviatile; lowest portion locally petroliferous

Diphu formation (Diphu River opposite Manipur Road), flaggy sandstones and shales, 3,500–5,000 feet. Thin- to thick-bedded flaggy sandstones with sandy shale interlaminations in upper part, dark gray silty shales with a few sandstone layers in lower part; probable lateral gradations from shales to flaggy sandstones from one locality to another; marine fossils including *Cyrena*, *Balanus*, and *Ostrea*, collected from middle portion; fossils also noted in basal portion. Mineral assem-

blages, as reported on by V. C. Illing, suggest flags and shales may be composed of materials derived from common source. Sandy beds are locally petroliferous

Zubza sandstones (part of "Coal Measures" of Pascoe), 1,925 feet or more (Zubza River 10 miles northeast from Diphu River)

Quartzose sandstones, with comparatively few accessory minerals such as zircon, tourmaline, and ilmenite; interbedded shaly carbonaceous sandstones, and sandy shales with thin coaly laminae; these observations applying to exposures on Zubza River, greatest thickness noted anywhere along Naga Hills front. In localities farther northeast, including Disai River, beds of coal 5 feet thick or more are common. Upper strata locally give rise to oil seepages

Stratigraphic correlations of the Naga Hills exposures with those in the Surma Valley region of lower Assam are in doubt, not only because of variations in composition, but also because of the intervening rugged country with complex structure. It is surmised, however, that the Zubza sandstones may be correlated with the Hatikhali sandstones.

In lower Assam, where structural trends change to north-south, a belt of comparatively simple parallel folding with inverted U-shaped profiles succeeds the decidedly asymmetric profiles farther northeast. Topographic expression is indicative of structure, the ridges commonly being anticlinal and the valleys synclinal. Westernmost folds are made up of strata high in the geologic column with lower horizons brought to the surface in successive folds toward the east. Thicknesses are great, with an amount as much as 20,000 feet for the Tertiary, according to measurements by L. G. Weeks, along the south side of the Jaintia Hills near Jaintiapur, where almost complete exposures are seen on several rivers. Summarized briefly, the succession there is as follows, in ascending order: (1) a thickness of about 1,000 feet of Cretaceous beds, consisting of sandstones, sandy shales, and carbonaceous shales with coal beds; (2) Eocene beds, including a basal sandstone overlain by nummulitic limestone and with shaly lignite near the top, the combined thickness being about 1,000 feet; (3) about 5,000 feet of massive sandstones, mostly thick-bedded and with little shale except in the upper part (probably related to the Hatikhali sandstone), with oil seepages rising along the outcrops of some of the upper sandy layers; (4) still higher exposures show a thickness of more than 12,000 feet, the entire series being decidedly sandy and consisting of alternations of massive, hard to friable sandstone, shaly sandstones, sandy shales and a little clay shale, and with but slight induration in strata of the higher part.

OIL AND GAS OCCURRENCES

There are two principal fields in Assam where oil is produced, Digboi in the extreme northeastern part and Badapur in the southwestern part. Oil and gas seepages are prevalent within and near these

fields, and also at many other localities, some of which are shown on the accompanying map (Fig. 5). In most instances the oil rises from sandy, carbonaceous strata of the lower part of the Tertiary, the age being Miocene or in part Oligocene. At Jaintiapur, lower Assam, the oil rises from near the top of a sandstone formation above the Eocene nummulitic limestone. A similar stratigraphical position is inferred for the Naga Hills region, though no exposures of Eocene strata have been noted there. Oil seepages are reported by W. J. Wright from Cretaceous beds in a river below Cherrapunji, south side of Khasi Hills.

Seepages of gas, either with or without oil, are fairly prevalent and are commonly seen rising in marshy ground around springs ("pungs"), the water of which may be charged with mineral matter and perhaps slightly salty. Such occurrences have a great stratigraphical range and do not necessarily signify a petroliferous character for the strata from which they rise. Some samples of the inflammable gas were found to contain no ethane.

Digboi field.—This field lies in the extreme northeastern portion of the Nage Hills at the edge of the lowlands, where beds of steep southeast dip suggest the presence of a compressed fold overturned toward the northwest. The field was worked in a small way by the Assam Oil Company as early as 1900; production was gradually increased up to 1915, when the company came under control of the Burmah Oil Company. The annual production at that time was about 122,500 barrels. The production in 1922 was about 133,000 barrels and in 1930 it was 1,099,216 barrels. The oil is reported to have a specific gravity of .85, and yields important products, including about 55 per cent kerosene, 15 to 20 per cent of lubricating oils, and 9 per cent paraffine wax of high melting point.

Badarpur field.—This field was discovered about 1910, when a shallow well was drilled near seepages of oil and gas. The Burmah Oil Company began active development about 1916, and by 1922 had completed about 50 wells, most of which were less than 1,000 feet in depth. The yield during that year was about 101,500 barrels. In 1926 about 20 wells were producing, most of which derived their oil from depths between 2,000 and 3,000 feet. During 1930 the production was 71,034 barrels, and in 1931 fell off considerably. The oil derived from shallower sands is heavy and dark and suitable chiefly for fuel purposes, but that from deeper horizons is reported as of somewhat better quality. High gas pressures are encountered in the deeper horizons. Dips on both flanks of the fold are steep, ranging from 50° to 75°, the east flank being slightly the steeper.

Massimpur.—Ten miles east of Badarpur is another structure, the Massimpur, where a few hundred barrels of oil were obtained from a well during the years 1928–30. High-pressure gas was encountered while drilling. The structure is approximately symmetrical in profile, with dips of approximately 45° on both flanks.

Dakshinbag.—This structure is located about 30 miles southwest from Badarpur. Development met with encouraging results in 1926, when considerable amounts of oil were obtained, together with large amounts of gas.

Patharia.—This recently discovered field in the vicinity of Badarpur produced less than 1,000 barrels in 1930 and 3,835 barrels in 1931.

Nichuguard.—Along the base of Naga Hills, opposite the Mikir Hills, is an overfolded and faulted anticlinal structure on which shales of the Diphu formation are exposed in several domal uplifts. Seepages show a light oil, rich in paraffine and in other respects suggesting that of the Digboi field. During the years 1926–27, three test wells were drilled by the Whitehall Petroleum Corporation, Limited, the first two being located about one mile southwest from Diphu River and the third two miles farther southwest. All of these wells were drilled into shales of the lower portion of the Diphu formation, the bottom of which was not reached although penetrated to a depth of 2,016 feet in the third well. Such thin sands as were encountered yielded showings of oil and gas. Drilling was discontinued after encountering evidence of having passed through zones of faulting, such as to suggest repetition of the beds.

EASTERN BENGAL

The north-south trending hill ranges of eastern Bengal are continuous with those of southern Assam and the two regions have many features in common. Geological conditions are similar, most hill ranges being anticlinal and intervening valleys synclinal. Formational units based on lithology are fairly constant and can be correlated with a fair degree of reliability from one range to another. Many seepages of gas rising from all formations, have been found in various districts investigated, but direct indications of oil are very few.

STRUCTURE AND STRATIGRAPHY

The region is composed of numerous anticlinal ridges lying approximately parallel with one another (Fig. 5). Some of the axes are continuous for nearly 100 miles with domal uplifts along them at intervals while others are more localized. Profiles are sharply compressed or rounded, depending partly on whether strata forming the crestal part are shales or sandstone and also on whether outcropping

strata lie high or low in the stratigraphical column, due to the fact that the older formations have undergone greater deformation. More or less asymmetry is common, but without uniformity; for example, the Sitakund anticline, near the coast, has a steepened west flank, while certain structures farther east are steepened on the east flank. Faulting occurs here and there, some structures showing transverse breaks along which the movement has been mostly vertical, while others show high-angle thrusting with displacement, in some instances, toward the west, and in others, toward the east.

Summit elevations are 1,000 feet or less along the westernmost ridges, increasing gradually eastward to slightly more than 2,000 feet within the Tertiary belt and to more than 8,000 feet along the Arakan Yoma, still farther east. Although there is a corresponding increase in the relief eastward, the transverse drainage lines are so arranged with reference to the formations which encircle the elongated domes of the several structures, that the older Tertiary strata are not exposed, this condition applying to most, if not all, of the mapped area shown in Figure 5. Explorations were not carried far enough eastward to study the zone of up-thrusting comparable with the "Boundary Thrust" of the Naga Hills, the existence of which has been verified, judging from statements by Pascoe (22, p. 314).

Stratigraphical thicknesses are great, comparable with those of lower Assam. F. B. Notestein and W. L. F. Nuttall, during field operations here, found 10,000 feet of Miocene and younger beds exposed on Gobomara anticline, near the town of Rangamati, and an additional thickness of more than 5,000 feet elsewhere. The following section is generalized from measurements of rock thicknesses at numerous places, with local formational names modified from those used during field work.

GENERALIZED STRATIGRAPHIC COLUMN IN DESCENDING ORDER

Baraiyadhala series (Pliocene?) 5,000–6,500 feet. (Named from a locality on Sitakund anticline.)
Coarse, ferruginous sandstones with fossil wood either silicified or carbonized ripple-marked sandy shales in lower part; rests unconformably on various older formations

Sitapahar sandstone (Lower Miocene?), maximum thickness 4,000 feet. (Named from exposures at Sitapahar Triangulation Station ten miles south of Rangamati.)
Coarse, friable, buff, well-bedded sandstones alternating with laminated sandy shales; marine fossils in basal portion indicate Miocene age. Forms low hogback ridges around most of anticlines excepting parts of Sitakund, where it is concealed by overlapping Baraiyadhala series

Foromon shales and sandstones (Lower Miocene?), 3,500–5,000 feet. (Named from exposures in vicinity of Foromon Triangulation Station 6 miles west from Rangamati.)
Composed of (a) upper, micaceous, silty clays and sandy clays, 1,800–2,500 feet thick, which have been eroded as strike valleys, and (b) lower sandstones, shaly to massive, 800–2,500 feet thick; commonly calcareous and conglomeratic in basal

portion and with a few marine fossils; locally in unconformable contact with underlying strata

Barkal shales and sandstones (Miocene and Oligocene?), 3,500–4,300 feet. (Named from exposures near Barkal, 13 miles northeastward from Rangamati.)
Composed of (a) upper hard sandy calcareous shales 900–1,200 feet thick; (b) middle shaly to massive sandstones, calcareous; (c) 1,200 feet of beds mostly dark bluish, well stratified shales with one sandstone member or more containing fossils, including shark teeth; these shales are exposed along Saichal anticline, 5 miles east from Barkal anticline, where seepage of light oil was found in beds of lower portion on Satrasuri Nala; lenses of lignitic coal seen occasionally; and (d) still lower strata including considerable friable sandstone interbedded with sandy shales, all of which are poorly exposed as seen on Aibarsarra Nala

The age of the lowest strata exposed is in doubt because no fossils could be found. It is probable that Eocene strata underlie this area, for they appear to the north in Assam, to the south along the Arakan coast, and to the east on the far side of the Arakan anticlinorium.

Most of the formational divisions listed, except the lowest, are exposed on the Sitakund anticline, northward from the town of Chittagong. Ravine sections in the central part show a thickness of about 2,200 feet of the Barkal shales and sandstones. Only 1,000 feet of the overlying Foromon sandstones are exposed in this vicinity, because they are overlapped by the Baraiyadhala series, Pliocene (?). The hiatus is not as great along the plunging part of the structure, where 3,500 feet of additional beds of the Foromon and Sitapahar formations are exposed. The thinning of formations across uplifts is not confined to this one zone as is suggested by local angular discordance along the contact of the Barkal beds with the Foromon.

OIL AND GAS OCCURRENCES

Gas seepages abound in nearly all parts of the area and rise from all formations, whether old or young. Most of the larger seepages rise along anticlinal axes or faults, but there are also conspicuous examples in synclinal positions. The one oil seepage is on the Saichal anticline, where a light oil rises from a sandy shale formation low in the stratigraphic column. The same horizon probably lies several thousand feet below the surface in all other structures examined.

The nearest oil seepages, both farther north in Assam, and south along the Arakan Coast, are more than 100 miles distant. This intervening seemingly barren area has led to much conjecture among those who have investigated the region. Pascoe (17, pp. 484–85), in discussing gas occurrences, states that parts of the Tertiary Gulf of Assam appear to be exclusively gas areas, one at the extreme head and another near the mouth, being respectively Namchik, in upper Assam, and Chittagong, near the Bay of Bengal. Apparently his studies in the Chittagong Hills were not in sufficient detail to lead to realization that strata exposed in that region probably are mostly

stratigraphically higher than the petroliferous series of Assam. While the presence of an underlying richly petroliferous series in the Chittagong Hills remains to be proved, no strong evidence to the contrary has been produced.

Sitakund.—Numerous gas seepages on this structure, as well as ease of access, encouraged drilling for oil, to depths of 1,800 to 2,500 feet. Strong flows of gas are reported to have been encountered in the deeper horizons. The geology of this locality is described in the memoir by Pascoe (22, pp. 311–313).

While only the Sitakund structure has been drilled in the hills of eastern Bengal, it is not improbable that large amounts of gas may be obtained at comparatively shallow depths in numerous localities.

OTHER PARTS OF INDIA

While the preceding descriptions treat of the more important regions where natural gas is to be found in commercial quantities, there are numerous other widely scattered regions with natural gas possibilities, some of which are summarized below.

Kashmir.—The Valley of Kashmir is an extensive mountain-locked basin in the western Himalaya, the floor of which consists largely of slightly consolidated lacustrine to fluviatile deposits, probably of post-Pliocene age. The general geological setting resembles that of Great Salt Lake Basin, Utah. Some of the beds are rich in plant remains with lignitic layers. Showings of gas have been found in wells drilled for water. Dips are, for the most part, gentle and such as to suggest depositional slopes, but there are a few anticlinal rolls as well as slight faulting. It is possible that gas may be encountered in commercial amounts at geologically selected locations. A brief sketch of the geology of Kashmir appears in the book by Wadia (13, pp. 335–381).

Bombay, Baroda, and neighboring coastal areas.—Bitumen has been noted in quarries on Bombay Island, where it occurs in cavities in a bedded basaltic rock. The occurrences described by C. S. Fox (26), are in rocks of Upper Cretaceous age. According to him, the series also includes intrusive dolerite, which cuts fresh-water sedimentary beds rich in plant and animal remains. The occurrence of bitumen is not a criterion of oil and gas possibilities.

In Baroda State, and also westward from Baroda along the coastal parts of Kathiawar and Cutch are fringes of late Tertiary strata which may contain gas. Small amounts of gas encountered in shallow wells near Broach, Baroda, have attracted attention in recent years.

Similar possibilities apply to the Madras coast and also the fringe

of Ceylon. Eruptions of the mud-volcano type have been reported in the sea adjacent to the Malabar Coast.

Andaman Islands.—These islands, together with the Nicobar group farther south, lie along a tectonic trend which, toward the south, aligns with Sumatra, and toward the north, with Burma. The geology of the islands has been described briefly by Tipper (26). The larger islands show small outcrops of serpentine and other rocks of pre-Tertiary age, overlain by sandstones, conglomerates, and other strata of Lower Eocene, portions of which are folded. These beds are overlain unconformably by Miocene limestones and clays which, for the most part, dip gently eastward. Both oil and gas may be present under suitable structural conditions.

BIBLIOGRAPHY[1]

1. W. T. Blanford, "Note on the Geological Formations Seen along the Coasts of Baluchistan and Persia, from Karachi to the Head of the Persian Gulf and Some of the Gulf Islands," *Rec. Geol. Survey Ind.*, Vol. 5, Pt. 2 (1872), pp. 41–45.

2. "On the Mud Craters and Geologic Structure of the Mekran Coast," *Quar. Jour. Geol. Soc.*, Vol. 30 (1873), pp. 50–53.

3. W. A. K. Christie, "Gas from a Mud Volcano in Mekran," *Rec. Geol. Survey Ind.*, Vol. 42 (1912), pp. 279–80.

4. W. T. Blanford, "Geology of Western Sind," *Mem. Geol. Survey Ind.*, Vol. 17 (1879), pp. 1–211.

5. W. T. Blanford, "Geological Notes on the Hills in the Neighbourhood of the Sind and Punjab Frontier between Quetta and Dera Ghazi Khan," *Mem. Geol. Survey Ind.*, Vol. 20 (1883), pp. 1–136.

6. E. W. Vredenburg, "Report on the Geology of Sarawan, Jhalawan, Mekran and the State of Las Bela, Considered Principally from the Point of View of Economic Development," *Rec. Geol. Survey Ind.*, Vol. 38, Pt. 3 (1909), pp. 189–215.

7. T. Hutton, "Notes on the Geology and Mineralogy of Afghanistan," *Calcutta Jour. Nat. Hist.*, Vol. 6 (1846), pp. 562–611.

G. de P. Cotter, "Report on Sanni Sulphur Mines," *Rec. Geol. Survey Ind.*, Vol. 50 (1919), pp. 130–38.

8. T. D. LaTouche, "Report on the Oil Springs at Moghal Kot in the Sherani Hills, with Second Note on Mineral Oil from the Sulaiman Hills" (by T. H. Holland), *Rec. Geol. Survey Ind.*, Vol. 25, Pt. 4 (1892), pp. 171–80.

9. R. A. Townshend, "Report on the Petroleum Exploration at Khattan," *Rec. Geol. Survey Ind.*, Vol. 19, Pt. 4 (1886), pp. 204–10.

10. R. D. Oldham, "Report on the Geology and Economic Resources of the Country Adjoining the Sind-Pishin Railway between Shahrig and Spintangi and of the Country between it and Khattan," *Rec. Geol. Survey Ind.*, Vol. 23, Pt. 3 (1890), pp. 93–110.

11. T. D. LaTouche, "Report on the Experimental Boring for Petroleum at Sukkur from October, 1893, to March, 1895," *Rec. Geol. Survey Ind.*, Vol. 28, Pt. 2 (1895), pp. 55–58, and p. 88.

12. W. L. F. Nuttall, "The Stratigraphy and Foraminifera of the Laki Series," *Quar. Jour. Geol. Soc.*, Vol. 81 (October 3, 1925), pp. 417–53.

———, "The Zonal Distribution and Description of the Larger Foraminifera of the Middle and Lower Kirthar Series (Middle Eocene) of Parts of Western India," *Sedgwick Museum* (Cambridge), Pt. 1.

13. D. N. Wadia, *Geology of India* (Macmillan and Company, 1926), 400 pp.

[1] In 1917 the Geological Survey of India issued a bibliography of Indian geology and physical geography with an annotated index of minerals of economic value. Twenty-six pages are devoted to petroleum. Natural gas receives no consideration.

14. W. L. F. Nuttall, "The Stratigraphy of the Upper Ranikot Series (Lower Eocene) of Sind," *Rec. Geol. Survey Ind.*, Vol. 65, Pt. 2 (1931).
15. B. Krookshank, "Oil Indications at Drigh Road, near Karachi," *Rec. Geol. Survey Ind.*, Vol. 60, Pt. 2 (1928), pp. 157–59.
16. E. S. Pinfold, "Notes on the Structure and Stratigraphy in the Northwest Punjab," *Rec. Geol. Survey Ind.*, Vol. 49, Pt. 3 (1918), pp. 137–60.
17. E. H. Pascoe, "Petroleum in the Punjab and North-West Frontier Province," *Mem. Geol. Survey Ind.*, Vol. 40, Pt. 3 (1920), pp. 493.
18. A. B. Wynne, "Notes on the Tertiary Zone and Underlying Rocks in the North-West Punjab," *Rec. Geol. Survey Ind.*, Vol. 10 (1877).
———, "Geology of the Salt Range in the Punjab," *Mem. Geol. Survey Ind.*, Vol. 14 (1878).
19. Robert Van V. Anderson, "Tertiary Stratigraphy and Orogeny of the Northern Punjab," *Bull. Geol. Soc. Amer.*, Vol. 38 (December, 1927), pp. 665–720.
20. J. M. Weller, "Cenozoic History of the Northwest Punjab," *Jour. Geol.*, Vol. 36 (1928), pp. 362–75.
21. C. S. Middlemiss, "Possible Occurrence of Petroleum in Jammu Province: Preliminary Note on the Nar Budham Dome of Kotli Tehsil in the Punch Valley," *Rec. Geol. Survey Ind.*, Vol. 49, Pt. 4 (1919), pp. 191–213.
22. E. H. Pascoe, "The Petroleum Occurrences of Assam and Bengal," *Mem. Geol. Survey Ind.*, Vol. 40, Pt. 2 (1914), pp. 270–329.
23. "Mineral Production of India during 1930," *Rec. Geol. Survey Ind.*, Vol. 65, Pt. 3 (1931), pp. 315–443.
24. E. H. Pascoe, "The Oil-Fields of Burma," *Mem. Geol. Survey Ind.*, Vol. 40, Pt. 1 (1912), pp. 1–269.
25. C. S. Fox, "A Contribution to the Geology of the Punjab Salt Range," *Rec. Geol. Survey Ind.*, Vol. 61, Pt. 2 (1929), pp. 147–79.
26. G. H. Tipper, "Geology of the Andaman Islands, with Reference to Nicobars," *Mem. Geol. Survey Ind.*, Vol. 35, Pt. 4 (1911).
27. W. R. Palmer, "Geology of a Part of the Khasi and Jaintia Hills, Assam," *Rec. Geol. Survey Ind.*, Vol. 55, Pt. 2 (1924), pp. 143–68.
28. E. Parsons, "Structure and Stratigraphy of the North-West Indian Oil Fields," *Jour. Inst. Petrol. Tech.*, Vol. 12 (1926), pp. 439–505.
29. E. S. Pinfold, Discussion of paper by Parsons, (28), *Jour. Inst. Petrol. Tech.*, Vol. 13 (1927), p. 339.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 18, NO. (MARCH, 1934), PP. 315-326, 5 FIGS.

NATURAL GAS FIELDS OF BURMA[1]

L. DUDLEY STAMP[2]
London, England

ABSTRACT

The gas occurrences are associated with the Tertiary rocks which now occupy the ancient gulf of central Burma, other occurrences with similar rocks of the Assam basin of deposition, which extended to the Arakan coast of Burma. Both oil and gas appear to have been formed under brackish-water conditions, being found neither in fresh-water sediments nor in deep sea-water deposits. Gas seepages are very common in Burma; many are dissociated from oil. Little use has been made even of extensive gas fields—even where one well yielded 39 million cubic feet per day—excepting in strategic localities. Other gas seepages are connected with the famous mud volcanoes, especially of Minbu and the Arakan coast. Much attention has been paid to the gas associated with the oil fields. Since 1908 there have been stringent laws regulating the conservation of gas pressures in the fields and the long life of the Burmese oil fields is attributed by many primarily to these regulations.

INTRODUCTION

The occurrences of natural gas are found in the same areas of India as the oil deposits, though the gas occurrences are more widely spread than are the commercially exploitable deposits of oil. The three main areas are: (1) in the province of the Punjab, northwestern India (with which may be considered also Baluchistan), (2) in the province of Assam, and (3) by far the most important, in the province of Burma.

As all important occurrences of gas and oil in India are found in Tertiary rocks, this account is restricted to the geology of Tertiary rocks.

TERTIARY GEOLOGY

In order to provide a clear background for the descriptions of gas occurrences which follow, it is necessary to give a brief résumé of the geology of Burma.[3]

[1] Manuscript received, February 11, 1932, for the Association's symposium on the natural gas resources of the world, a volume whose scope was subsequently restricted to North America. The manuscript of the paper on Burma has been revised (November 23, 1933), and the author has given permission for its publication in the Bulletin.

[2] London School of Economics, University of London.

[3] For further details see: L. D. Stamp, "Conditions Governing the Occurrence of Oil in Burma," *Jour. Inst. Petrol. Tech.*, Vol. 13, No. 60 (February, 1927), pp. 21–52; "The Connection Between Commercial Oil Deposits and Major Structural Features with Special Reference to Asiatic Fields," *ibid.*, Vol. 14, No. 66 (February, 1928), pp. 28–52; "The Oilfields of Burma," *ibid.*, Vol. 15, No. 74 (June, 1929), pp. 300–45.

The general geology of Burma is relatively simple and controls the topography to such a marked extent that the natural geographical and geological units in the country closely correspond.

The country may be divided into four parts.

1. *Eastern massif of old rocks.*—The whole eastern part of the country, including the Shan states and Tenasserim, consists of a massif of hard, old rocks ranging in age from pre-Cambrian to Jurassic. The whole area, with the exception of several old lake basins, has probably been land since the latter part of Mesozoic time. The massif forms a plateau with an average elevation of 3,000 feet. The western edge is clearly defined, being marked by the conspicuous line of hills familiar to every traveler by train from Rangoon to Mandalay. Along this line the Tertiary rocks dip sharply away from the old massif, but the junction is rarely visible.

2. *Western fold ranges.*—In the west part of Burma the dominating feature is a great chain of folded mountains. The chain is complex and broad in the north, where it forms the Naga, Chin, and other groups of hills, but narrows southward to form the Arakan Yoma. The actual physical structure terminates in Cape Negrais, but structurally the same fold continues southward through the Andaman and Nicobar islands into Sumatra. In Burma several peaks reach 10,000 feet. Very little it known of the geology of the chain. The structure appears to be anticlinorial, with a central core of crystalline rocks. Triassic, Jurassic, and Cretaceous rocks are involved in the folding, as well as the Tertiary rocks on the flanks. There is good reason to believe that the folding originated in Cretaceous or earlier time and increased gradually during the Alpine movements of the Tertiary period. The fold gave rise to a narrow land barrier from Eocene time onward.

3. *Central Tertiary basin.*—Between the Arakan Yoma on the west and the Shan Plateau on the east lies the great region of Tertiary rocks in Burma. It corresponds with the basins of the Chindwin-Irrawaddy and Sittang rivers, and it is in this region that the petroliferous areas of Burma are found.

4. *Arakan Tertiary region.*—Between the Arakan Yoma and the Bay of Bengal lies another area of Tertiary rocks, forming part of the Assam area of deposition.

In early Tertiary time Burma may be pictured as partly covered by a long, narrow gulf of the sea, with the Shan Plateau forming the land mass on the east and the central ridge of the Arakan Yoma forming a narrow strip of land on the west. This strip of land may

have been a peninsula separating the Burma and the Assam areas of deposition, or it may have been a long narrow island. In the latter case the retention of the term "Burma gulf" is still justified because deltaic or fresh-water conditions prevailed at the northern end.

More correctly one might refer to the Burma twin gulf, for it was divided into two parts by a central, longitudinal ridge. The western part corresponds with the Chindwin-Lower Irrawaddy valley of the present day: the narrower eastern part with the upper Irrawaddy-Sittang valley. The central ridge may have been only a submerged ridge, but it was sufficiently important to cause a marked difference in the deposits in the eastern and western parts of the gulf. All the oil fields occur in the western gulf. The site of the old central ridge is marked today by extinct volcanoes and, in the south, by the hills known as the Pegu Yoma.

The whole double gulf must have been broader than appears at the present day, owing to the extensive, lateral compression and folding which has since occurred. The gulf opened to the sea toward the south, but into northern parts there probably poured several great rivers. Possibly the Tibetan course of the Brahmaputra is a remnant of one of these river systems; at a later stage, rivers of which the Chindwin and Irrawaddy are the present-day representatives took its place. The whole history of the Tertiary period in Burma may be summed up as the story of the infilling of the twin gulf by river-borne sediments from the north and by marine sediments in the south. On the whole, therefore, there has been a spreading of continental conditions from the north, pushing the marine waters farther and farther south. This process is still going on, and year by year the delta of the Irrawaddy encroaches on the shallow Gulf of Martaban.

The gradual infilling of the trough has, however, been interrupted at intervals by lateral folding movements. These movements resulted in the gradual uplift of the Arakan Yoma and, at a later stage, of the Pegu Yoma and other folds. Each movement of folding, however, caused a temporary increase of the depth of the center of the basin and a consequent return northward, in the center, of marine conditions. Thus it is found that the gradual southward retreat of the sea was interrupted at intervals by temporary northward movements which have left their mark as wedges of marine strata tailing out northward. There is also marked variation in the character of rocks from east to west, across the gulf, and a certain amount of the sediment of these rocks must have been derived from the denudation of the Arakan Yoma land, while littoral conditions must have prevailed along its margins.

In a general way the same statements may be applied to the Arakan-Assam gulf of deposition. The writer's personal knowledge

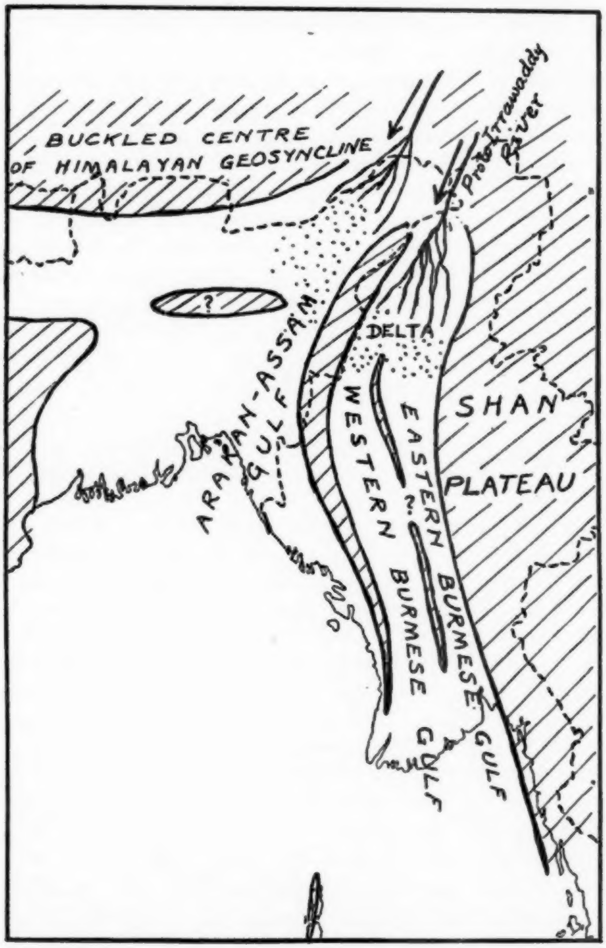


FIG. 1.—Early Tertiary geography of Assam and Burma.

of this area is limited to the Chittagong district of Bengal and the Arakan coast lands of Burma but, apart from the necessarily different Tertiary sequence and the greater intensity of folding generally found

among the Tertiary rocks, the conditions closely resemble those in the Burma gulf.

The Tertiary rocks of central Burma fall into three main divisions: (1) Irrawaddian (Mio-Pliocene), (2) Peguan (Oligo-Miocene), and (3) Eocene.

All horizons from the middle of the Eocene to the top of the Peguan may be petroliferous. The oil in the producing fields is obtained from horizons extending from the top to the base of the Peguan and probably into the higher Eocene. The occurrences of natural gas are even more widespread. Indeed, it may be said that natural gas

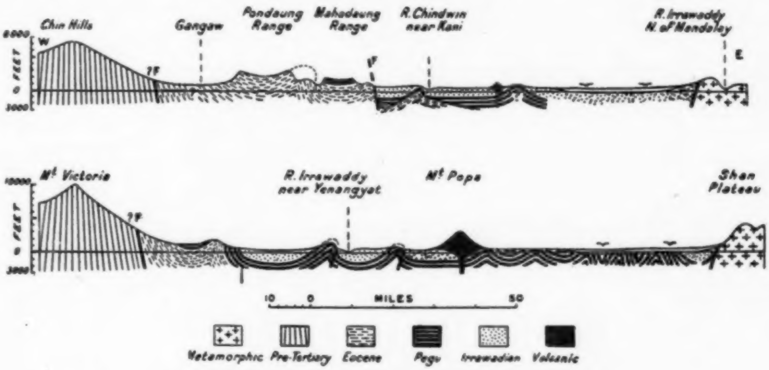


FIG. 2.—Sections across the central valley of Burma.
(From *Jour. Inst. Petrol. Tech.*, 1927.)

occurs in all the existing oil fields and in addition in many areas which are structurally comparable, where the lithological character of the rocks is similar to that of those in the oil fields. Burma abounds with examples of promising "structures" which have good gas showings but which have failed to yield oil.

But both gas and oil are very closely related to the conditions under which the containing beds were laid down for, with the close alternation of clays and sands found throughout the Tertiary sequence, most areas seem to demonstrate clearly that migration of both oil and gas has been mainly or entirely lateral migration—along the bedding planes of the rocks. Both oil and gas are absent from freshwater sands (Irrawaddian) and fresh-water clays (with remains of crocodiles, turtles, and mammals); the deeper marine-water clays are equally devoid of gas and oil. *All the gas and oil horizons are definitely associated with intermediate conditions.*

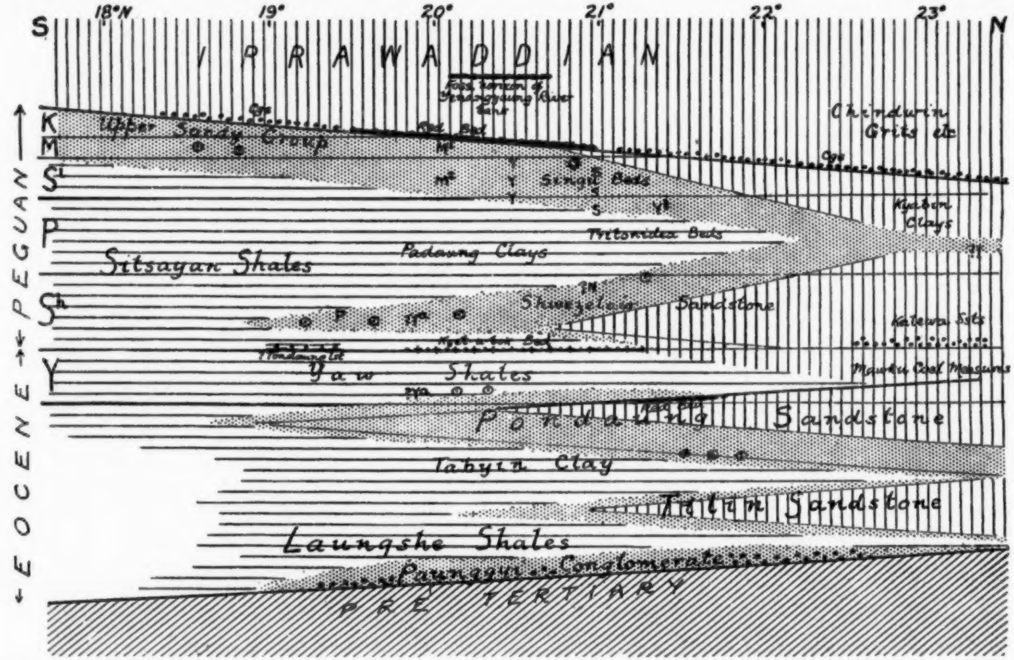


FIG. 3.—Diagrammatic section from south to north through Tertiary trough of Burma. (From *Jour. Inst. Petrol. Tech.*, 1927.)

LITHOLOGY

Vertical lines = fresh-water beds; nearly all with silicified fossil wood and some remains of mammals, crocodiles, and turtles. Mainly coarse sands.

Dotted = marine and estuarine beds, mainly sandy.

Horizontal lines = marine and brackish-water beds, predominantly clayey.

PALEONTOLOGY

Y—Yaw stage; *Sh*—Shwezetaw stage; *P*—Padaung stage; *Si*—Singu stage; *M*—Migyaungye stage; *K*—Kama stage.

OIL GEOLOGY

?I = Probable oil horizon of Indaw;
Yt = Oil horizon Yenangyat;
S = Oil horizons of Singu;
Y = Oil horizons of Yenangyaung;
M^1 = Oil horizon of Minbu (N);
M^2 = Oil horizons of Minbu (Yethaya and Tagaing);
P = Oil horizon of Padaukpin;
?Ya = Oil horizon of Yenanma (alternative);
?N = Probable oil horizon of Ngahlaingdwin;
⊙ = Oil horizons not commercially exploited.

The diagrammatic section (Fig. 3) illustrates the relationship between the paleontological stages (shown between horizontal lines) and the lithological stages. The upper oil and gas-bearing horizons pass into younger and younger beds from north to south. This figure

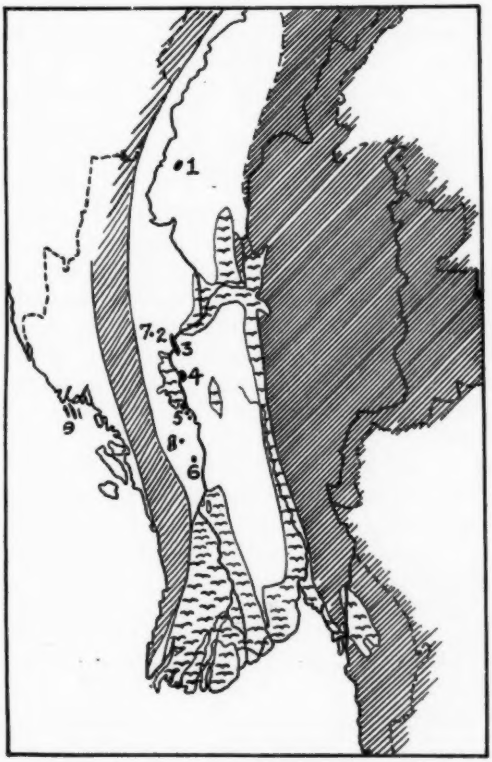


FIG. 4.—Map showing position of oil fields of Burma.
1—Indaw; *2*—Yenangyat; *3*—Singu; *4*—Yenangyaung; *5*—Minbu; *6*—Padaukpin; *7*—Ngahlaingdwin; *8*—Yenanma; *9*—Arakan. Heavily shaded area on east is Eastern massif of old rocks; that on west is Western fold ranges.

is a diagrammatic section from south to north, that is, ***longitudinally*** through the Tertiary trough. The figure has been somewhat simplified. There are, for example, subsidiary wedges of sandstone in parts of the Sitsayan shales which have not been indicated.

Because time planes have been chosen as the horizontal datum lines on the diagram, thicknesses of the beds are now shown to true scale.

GAS OCCURRENCES

In the preceding section it is indicated that the gas and oil occurrences are definitely related to certain types of lithology and are found in a great variety of geological horizons.

The gas occurrences are far too numerous to mention individually, because they are found throughout a belt of country extending for at least 700 miles north and south as well as along the Arakan coast. For convenience they may be grouped into three artificial (and not very clearly differentiated) groups: (1) gas showings not associated with an oil field; (2) mud volcanoes; and (3) gas occurrences associated with the different oil fields.

GAS SHOWINGS NOT ASSOCIATED WITH AN OIL FIELD

Simple gas seepages are very common and widespread in Burma. Again and again they have been taken to indicate the possible presence of oil and many a "structure" has been drilled on the evidence afforded by gas seepages in the vicinity. Ordinarily the gas seepages are most evident in the rainy season: the gas may bubble up through the water covering a rice field in amounts sufficient to damage crops. Ordinarily the seepages are small—a few bubbles bursting slowly and occasionally a few globules of oil floating in the vicinity.

In other places there is a strong and steady escape of gas from fissures in the ground. The writer visited a gas seepage on a small hill just east of Natmidauk village, where upper sandy beds of the Peguan are exposed. When a match was applied to the seepage there was an explosion and flames rose to a height of about 3 feet. After burning for 20 minutes the fire could not be extinguished. This seepage is located near the nose of a pitching fold. Nearly 6 miles northeast there is an oval inlier of Peguan—structurally ideal for a small oil field. A well located by the writer on this inlier obtained only a small showing of oil in an upper horizon, but after passing through a great thickness of shale, encountered a gas-bearing sand at 2,000 feet. The gas was sufficient to blow the drilling tools out of the hole and the noise of escaping gas could be heard 12 miles away. The Indian paper, *Capital*, gave the following details in its issue of September 20, 1928.

> At the Indo-Burma Petroleum Company's gas well at Pyayè for eight months an average of 39 million cubic feet of gas were lost every day, equivalent in thermic value to about 5,000 barrels of oil a day. This gas well has now been closed in under the orders of Government.

This particular case[4] is interesting for several reasons: (1) it is believed to be the largest gas well completed in India or Burma;

(2) it added another to the long list of gas occurrences dissociated from oil; and (3) it illustrates the negligible value of natural gas except in strategic localities. Had the area been more readily accessible to the existing oil fields the gas would, of course, have been utilized.

Records of gas showings and seepages (known up to 1911) are published in Pascoe's "Oilfields of Burma."[5]

MUD VOLCANOES

The mud volcanoes for which Burma has long been famous—those at Minbu were noted as long ago as 1855 by Thomas Oldham, the "father" of the Geological Survey of India—differ from the simple gas seepages mainly in that the escaping gas brings up large quantities of pale gray mud. The most famous of the mud volcanoes are those on the Arakan coast (notably the island of Cheduba) and those at Minbu. The former have not infrequently given rise to evanescent islands along the coast and at times have erupted with startling rapidity and the gas has caught fire. An eye witness to an eruption in Cheduba in 1903 says

> I saw what at first I took for a black cloud, but which no doubt was mud, shoot far above the trees, followed a moment after with very dark red flames and dense black smoke which looked to me to shoot right up to the clouds.

The Minbu volcanoes lie along an important fault, and about 2 miles south of a group of oil-producing wells at the north end of the Minbu field. There are ordinarily seven or eight vents, and not infrequently the mounds of pale gray mud reach 100 feet in height. In other cases the "volcanoes" are simply broad pools of fluid mud through which huge bubbles of gas rise and burst every 10 or 15 seconds.

Similar mud volcanoes, but on a small scale, have been examined by the writer in many parts of Burma. Over the crater of one in the Chindwin district a trestle was rigged and water successfully boiled by igniting the gas. This gas occurrence was near the crest of a very sharply folded anticline.[6]

The mud brought up by these volcanoes is cold. It resembles the mud washed out of holes drilled by percussion tools. The gas seems to cause extensive underground movement of water, probably in the finer water sands, causing the water to wash out the mud from such

[4] See details given under Pyayè in Stamp, "The Oilfields of Burma," *op. cit.*, sup. p. 336.

[5] *Geol. Survey of India Memoirs* (1912).

[6] Described in Stamp, "Geology of Part of the Pondaung Range," *Trans. Mining Geol. Inst. of India* (1922).

beds, or from the surface of near-by clayey layers. The gas then forces the muddy slime through any available cracks to the surface. In many sections, the Peguan rocks—the main oil-bearing rocks of Burma

FIG. 5.—Crater of active mud volcano, Minbu, 1925.

—are found to be seamed with irregular mud veins and filled-in fault fissures doubtless caused in this way. Many of these mud veins effectively seal oil sands. They are very numerous in the Yenangyaung

oil field and may be considered the cause for the amazingly variable yield of oil from wells many of which are only 20 yards apart.

GAS OCCURRENCES ASSOCIATED WITH DIFFERENT OIL FIELDS

By far the most important of all the oil fields of Burma are those of Yenangyaung and Singu. Singu has the greater reserves and is likely to become the biggest producer in the near future, but the most famous is undoubtedly the Yenangyaung field.

In many ways the oil field of Yenangyaung is one of the most remarkable in the world. Up to the close of 1933 it is estimated to have produced 3,800 million gallons of oil, this quantity having been obtained from an area of a little more than a square mile. The oil has been exploited by native methods for at least 200 years, but the development of the oil field by modern methods and European companies began in 1887 or 1888 when the Burmah Oil Company first produced oil there. Nearly the whole field is covered with a maze of derricks, for the well sites are only 60 feet apart and there is, in the competitive drilling areas, an extraordinarily intense competition; but the yield of oil in the field to-day is nearly the same as it was 20 years ago. Yenangyaung does, indeed, afford a classic example of what must be called the conservative exploitation of an oil field and it is safe to say that the continuance of the output at a uniformly high level has been very largely due to the conservation of gas pressure from earliest days to the present.

Yenangyaung owes its preëminence as a producer to several factors. 1. It is situated in the heart of the ancient Tertiary belt of Burma where conditions remained suitable for the deposition of oil-bearing sediments for a long time; the oil measures are correspondingly very thick. 2. The field is a dome with gentle dips on either side and a steady, gentle pitch north and south.[7] The Peguan rocks are exposed in an area almost 5 miles long from north to south, but only a mile in width. 3. The field has an excellent gathering ground. There is neither anticlinal nor domed structure for many miles in any direction.

In some respects the Yenangyaung field is a text-book example of anticlinal structure. Toward the crest of the dome there is a gradual decrease in the specific gravity of the oil just as one is led theoretically to expect. Near the crest the oils are lightest and are very heavily

[7] *Editor's note.*—D. Dale Condit advises the editor that a slight asymmetry of the fold has only recently been recognized and that transverse faulting in the Yenangyaung field may have influenced the erratic distribution of gas. The author agrees that the importance of faulting has previously been underestimated, partly because the fault planes are marked by infillings of mud and are difficult to distinguish from other "mud veins." The asymmetry has meant the extension of deep drilling down the gently dipping eastern limb.

charged with gas. In the early history of the field there were flowing wells, and many gas wells near the crest of the fold that eventually produced oil. All the oil sands at Yenangyaung are lenticular, and it is practically impossible to correlate them from well to well, spaced 20 or 30 yards apart. In the southern part of the field, some distance from the crest, there is a rich gas-bearing area, which has failed to yield oil. In this area it is found that the mud veins previously mentioned are extraordinarily plentiful, and it has been suggested that these mud veins have sealed off the southern part of the field from the northern part.[8] Hopes had long been entertained that the southern blocks of the field, farther south than this gas-yielding area, would eventually produce oil, and the first strike was made at 4,000 feet in 1930.

The gas occurrences in the Yenangyaung field may therefore be separated into two groups: (1) occurrences of the gas field south of the oil field proper, and (2) occurrences in the oil field itself.

Gas field of Yenangyaung.—Edwin Pascoe,[9] in his account of the oil fields of Burma written in 1910–11, refers to two early gas wells found in the southern tract. He says that in the more southerly of them the pressure, according to the guage, measured 500 pounds to the square inch, and the pressure in the well when first opened was said to have been as much as 800 pounds. No serious attempt has been made to utilize gas from this area.

Gas occurrences in oil field itself.—Wells near the dome or the central part of the field had a very gassy oil which flowed sometimes to a considerable height, and it was in this area that at least a well or two produced large volumes of gas and later oil. It was also observed that the flow of nearly all wells at Yenangyaung was intermittent. Even when the flow was continual, the rate varied periodically.

Although many believed that hydrostatic pressure caused the wells to flow, early recognition of the rôle of gas in the production of oil led to legislation which prohibited the waste of gas in the Yenangyaung oil field. Since 1908 there have been stringent laws regulating the conservation of gas pressure in the field. Flowing wells are now unknown on the Yanangyaung field; the oil is obtained by pumping. There is not the slightest doubt that early measures conserving gas pressures caused the extremely long life of many of the Yenangyaung wells and indeed of the field as a whole.

[8] *Editor's note.*—The faults previously mentioned may have controlled the accumulation of gas only in this restricted area.

[9] *Op. cit.*, sup., p. 85.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 18, NO. 3 (MARCH, 1934), PP. 327-342, 4 FIGS.

GEOLOGY OF HUNTINGTON BEACH OIL FIELD, CALIFORNIA[1]

HOYT S. GALE[2]
Los Angeles, California

ABSTRACT

Review of the several reports on current developments in the Huntington Beach oil field suggests a somewhat closer coördination than is generally given of the oil zones of the various areas into which the field has been subdivided, for the purpose of tracing the probable paths by which the oil has migrated into the several parts of the field. The influence of faulting appears to have been important in this connection. The inference is drawn that the tidelands area, which has lately come into prominence, probably includes the main structural axis of the whole area, and some significant clues to the submarine structure are found in air photographs.

GENERAL CONDITIONS

Geologically the Huntington Beach oil field is a structural "high" in the line of uplift that extends from Beverly Hills to Newport Beach. This line of uplift includes some of the most important oil fields in California. In all of these structures the oil has accumulated in Tertiary rocks that have been folded into domal anticlines at more or less regular intervals along the line of uplift. Most of these folds are somewhat complicated by faulting roughly parallel with the trend of the main uplift and the axial directions of the folding. Figure 1 is a map of the general geology of Los Angeles Basin, showing the main lines of geologic structure and the relation of the Huntington Beach area to the Newport-Beverly Hills line of uplift.

CHARACTER OF GEOLOGIC INFORMATION

The geological structure of the Huntington Beach area is very complex and is imperfectly understood by geologists. Some of the major structural features seem clear, but it is recognized that the area involves much faulting and some folding of the strata that can not be defined from present incomplete data. The oil-zone beds are lenticular and vary in character from place to place so that exact correlation has seemed almost impossible. Lately micropaleontological markers in the stratigraphic section, obtained by study of materials from the core samples, are believed to have yielded much more

[1] Read in part before the Pacific Section of the Association at Los Angeles, November 9, 1933. Manuscript received, November 15, 1933.

[2] Consulting geologist, 1775 Hill Drive.

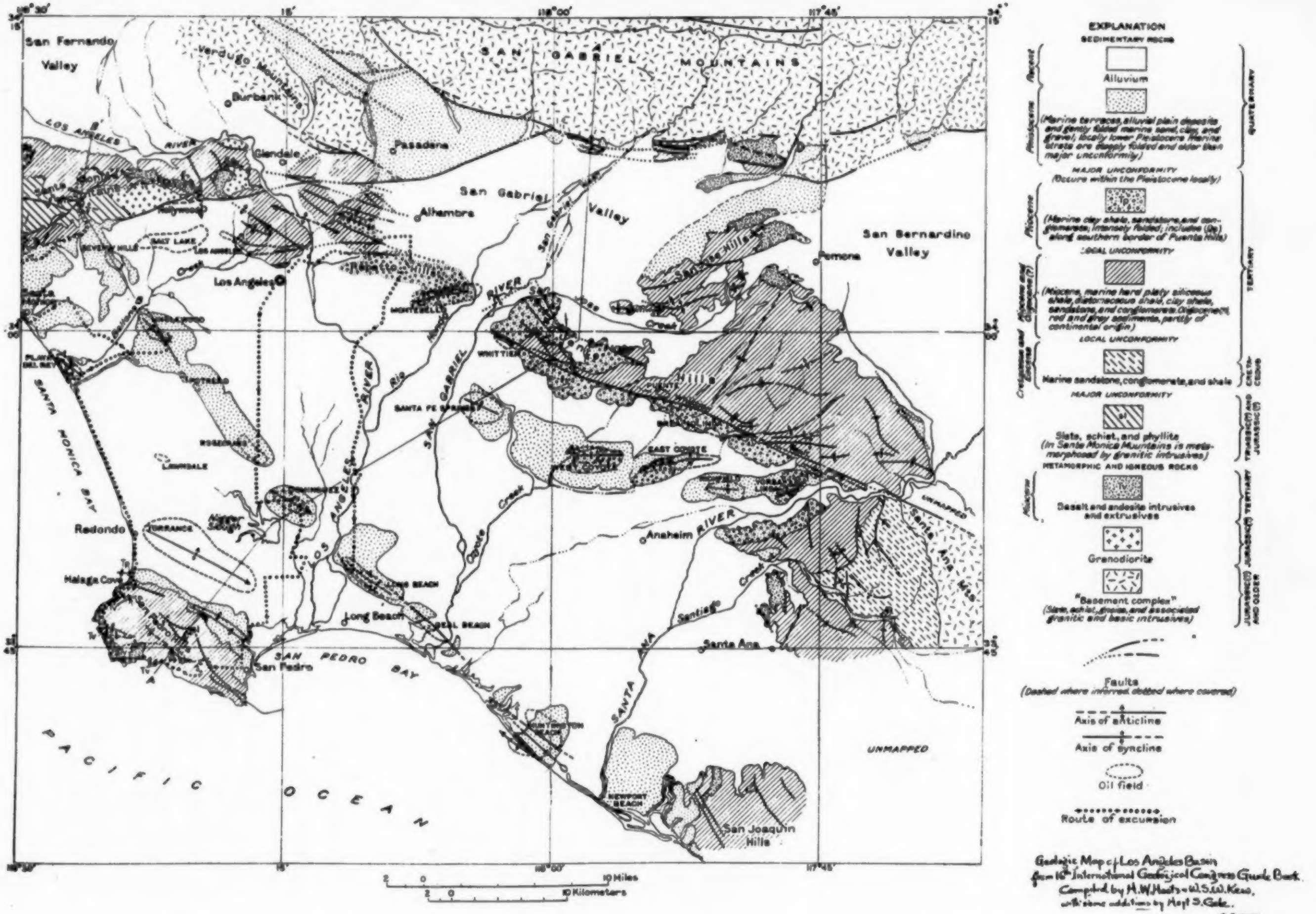


FIG. 1.—Geologic map of Los Angeles basin, reproduced from *Guidebook to Southern California, 16th Internat. Geol. Congress* (1933), compiled by H. W. Hoots and W. S. W. Kew with addition of some details by Hoyt S. Gale.

satisfactory information on this subject, but as yet the data available are fragmentary and scattered, and it is obvious that all such information will have to be interpreted in the light of possible deviation of the wells from vertical, if the data from them are to be used in an engineering sense.

GEOLOGY OF OIL-BEARING FORMATIONS

The geologic age of the oil-bearing formations at Huntington Beach ranges from early Pliocene to late and perhaps Middle Miocene. Most of the oil-zone beds are included in the Lower Pliocene Repetto formation, but the deep-zone production of the Old Field, Barley Field, Townsite, and Surf areas is derived directly from Miocene rocks. The strata encountered in the drilling of wells begin at the surface with 450–700 feet of unconsolidated sand, gravel, and blue clay, usually classed as of Pleistocene age. These are underlain by more compact deposits of blue and gray shales, coarse sands, gravel, and sandy shales, which as a unit are usually called the Pico formation of Upper or Middle Pliocene age. The Pico has an aggregate thickness of about 1,300 feet. The Pico is in turn underlain by brown sticky shale or silt, in thin-bedded laminated deposits including some sands which form most of the productive oil measures of the field. This is the Repetto formation, which is of Lower Pliocene age. The Repetto has an aggregate thickness of about 900 feet. This extends to the base of the Pliocene series.

The Pliocene is underlain by shales, commonly thin-bedded, including some sands, forming a unit known as the Puente or Modelo formations in and around the Los Angeles Basin, or the Monterey formation of many California geologists. This is of Miocene age and includes the deep-oil zones already mentioned. There is some evidence that the Pliocene rests unconformably on the Miocene in various places around the Los Angeles Basin, where the contact of these two units can be observed in outcrops. The Miocene is supposed to be the principal source of the oil-producing materials in this general region.

The interpretation of geologic events most directly related to the occurrence of the oil at Huntington Beach may be stated as follows. In the Miocene epoch of geologic time and perhaps also in the Pliocene epoch, organic substances capable of being converted into oil under certain conditions of burial and preservation, were deposited on the floor of an embayment of the ocean which at that time covered all of the area in and around the present site of Huntington Beach. These substances are believed to have consisted of accumulated remains of

myriads of minute organisms deposited with mud in blanket-like layers on the ocean floor, forming an ooze. At times, during the deposition of these materials, storm waters carried coarser-grained sediments from adjoining land surfaces, forming layers of sand on the ocean bottom; when the storms had passed, the accumulation of

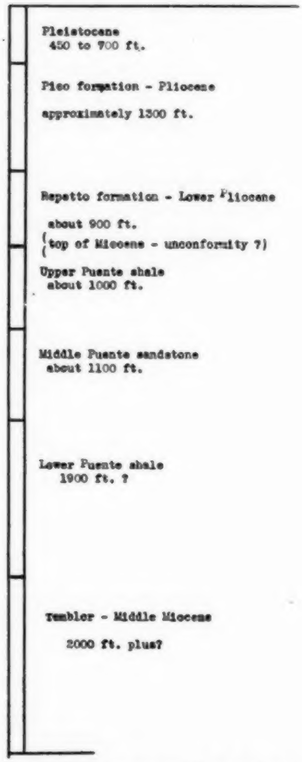


FIG. 2.—Generalized stratigraphic section of Huntington Beacn oil field, after George H. Doane.

ooze continued. Thus there was formed a succession of layers of ooze and sandy beds. As the layers of sand and of mud and organic matter piled up, the lower layers were squeezed and compressed by the weight of the overlying deposits, and much of the water that was originally mixed with the mud was gradually forced to filter out, while mixtures of water and of the oil formed by the alterations of the

enclosed organic matter tended to lodge in the porous sandy layers, where the spaces between the grains were larger than in the mud.

This process continued for millions of years until tremendous masses of material were piled up, building several geologic formations. The beds lay for a long time flat on the ocean floor, or nearly so, as they were when they were first deposited. In the early and middle part of the Pleistocene, the last of the geologic periods, the district which is now Huntington Beach was subjected to disturbances that were part of one of the great mountain-building epochs that affected the whole Pacific Coast border of the American continent. This caused the ocean floor at the site of Huntington Beach to be arched upward, raising it above sea-level in a long ridge, which was part of an uplift that extended northwestward through the site of Signal Hill and through Inglewood to Beverly Hills. At Huntington Beach and at other places more or less regularly spaced along this line of uplift, the high parts of these folded strata have assumed the form of somewhat symmetrical anticlines or distinct domes in many places broken or split by faulting. Huntington Beach is one of these domes broken into longitudinal blocks approximately parallel with the trend of the main line of uplift which is here parallel with the coast line. There are at least three main faults in the Huntington Beach field, dividing it longitudinally into four main divisions, which are described separately in the following paragraphs.

TOPOGRAPHIC AND STRUCTURE MAP

Figure 3 is a map showing part of recent topographic surveys by the United States Geological Survey. The surface relief is shown by contours of 5-foot vertical intervals, which—it so happens—also express distinctly some of the main features of the geologic structure, especially the major fault traces. The faults being the boundaries of the blocks which are the basis of subdivision of the field, this map also serves as an index for reference in the following descriptions.

DIVISIONS OF THE HUNTINGTON BEACH FIELD

The Huntington Beach field is divided into a number of areas that differ more or less in structure and depth or sequence of the oil-zone beds as shown by drilling. These divisions are: (1) the Old Field area, in which commercial production was discovered and first developed, which covers approximately the northeastern half of the field; (2) the Main Street area, occupying the central southeastern portion of the old city of Huntington Beach; (3) the Barley Field and Townsite areas and probably also the small Surf area, sometimes

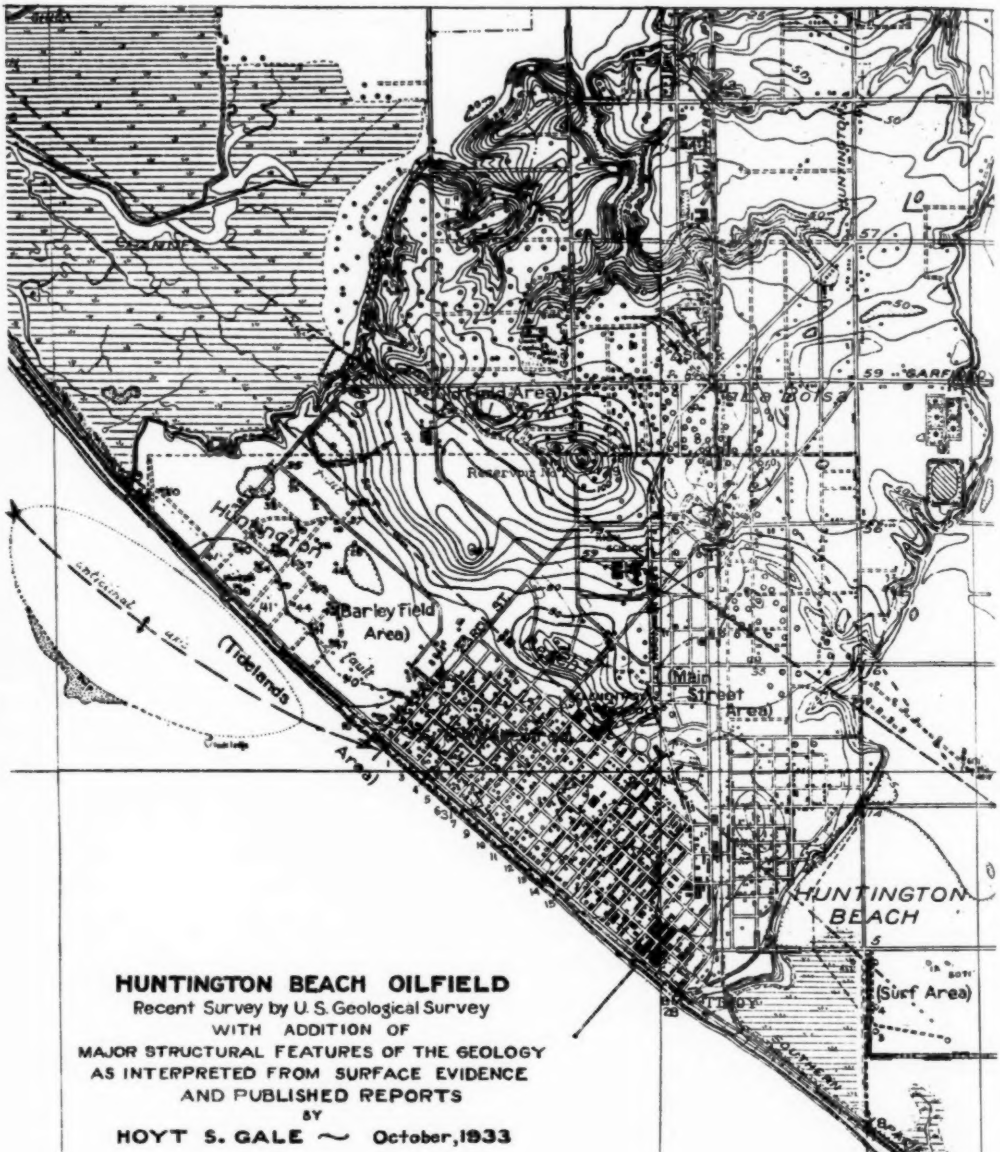


FIG. 3.—Huntington Beach oil field, recent survey by United States Geological Survey, with addition of major structural features and other details.

discussed separately, but really adjoining and related districts occupying a belt of lands parallel with and near the coast, limited on the ocean side by Ocean Avenue as usually described and not considered to include the railroad right of way, or the beaches, or the tidelands; and (4) the Tidelands area extending from the beach out under the ocean bottom within the limits considered to lie within the jurisdiction of the State.

OLD FIELD AREA

The largest division of the Huntington Beach oil field, which is the one situated farthest inland, is known as the Old Field area. Commercial oil was discovered here by the Standard Oil Company in a well brought into production on May 24, 1920. As production was extended by the drilling of other wells, it became obvious that the geological structure of this part of the field was essentially that of a homocline, with productive accumulation in the higher parts of the northeastward-dipping beds or strata. This area, or strip, or fault block, as it may be variously called, is cut off on the southwest by a fault, the surface trace or outcrop of which passes immediately north of the Huntington Beach Union High School. In the following discussion, this fault is therefore called the High School fault. The strata composing the fault block dip fairly regularly northeast, away from the fault.

Oil is found in the Old Field area in two main sandy zones, each of which is divided into an upper and a lower part with a less productive part between. The two parts of the upper zone are known as the Upper Bolsa and the Lower Bolsa zones, and the parts of the lower zone are known as the Upper Ashton and the Lower Ashton zones. There is also an unimportant tar zone above the Upper Bolsa. The oil appears to have migrated into these reservoir beds, coming from the northeast up the dip in the Ashton zones, and to have accumulated against the High School fault.

It is understood that oil which has collected underground in porous sandy beds is usually subject to hydrostatic pressure operating through the water that occurs beneath it or mixed with it, and oil being lighter than water tends to rise to higher and higher levels until there are no more passageways in porous beds or openings along faults that it can follow; but it can not migrate through the denser layers of mud or shale if they are continuous and unbroken. Hence, when the Huntington Beach area was uplifted into a broken dome along an anticlinal axis, the oil tended to migrate upward along the tilted sandy strata and along faults that had produced open channel-

ways to the highest place it could reach before being trapped by masses of shale. Where a shale bed had been brought by faulting opposite to a sandstone bed, the migration of the oil in the sandstone bed is blocked. In such case the oil may either accumulate there, forming an oil pool, or, if the shale has passageways in the plane of the fault, the oil may migrate along such passageways around the shale into the nearest sandstone above, either on the same side of the fault or on the other side, and continue in that sandstone until it reaches the top of the anticline or dome, or is blocked by another fault, or can find no other place to go upward through porous beds.

Tar sands are scattered through the deposits overlying the oil zones, but the top of the first productive oil zone as reported in the early development of the Old Field area lay at depths of 1,850–2,000 feet below sea-level in a narrow belt on the highest part of the field along the High School fault. The gravity of the oil from the Upper or Bolsa zones ranges from 14° to 19.5° Bé., apparently influenced by local conditions. The Lower or Ashton oil zone has now been subdivided into a series called the Upper, Intermediate, and Lower Ashton oil zones, with various intermediate sands carrying water and a bottom water defining these limits. Gravity from the Ashton zones ranges from about 19.5° to 27.5° Bé., the gravity generally increasing gradually with depth in the section, excepting in the outer borders of the field. Table I is an approximate summary concerning this series of oil zones, which is distributed within a vertical range of about 3,000 feet.

TABLE I

Zone	*Maximum Thickness (Feet)*	*Gravity of Oil Degrees Bé.*	*Remarks*
Upper Bolsa	160–250	14–16	Predominantly sand
Interval—mostly shale	500?		(separated by an intermediate water)
Lower Bolsa	160	18–19.5	
Unproductive zone	200±		"Copeland water" in upper part
Upper Ashton	175	19.5–20.5	
Intermediate water sand			"Porter water"
Intermediate Ashton	500	21.5–24	Predominantly shale.
Intermediate water sand			"Brown water"
Lower Ashton	650	25–27.5	Predominantly sand.
Bottom water zone			"Pearce water"

A profile cross section of the Old Field area drawn to illustrate the relationships of producing oil formations and water conditions, contained in Vol. 9, No. 6, *Summary of Operations of the State Mining Bureau*, is apparently significant as to the main reservoir of the oil

in the lower zones and its migration into the Bolsa zones along the High School fault.

MAIN STREET AREA

The next strip or block southwest of the Old Field area is known as the Main Street area. This block of strata was depressed along the High School fault so that the Bolsa zone in the Main Street area is approximately opposite the Ashton zone in the Old Field area. The oil appears to have migrated across the fault from the Ashton zone in the Old Field area to the Bolsa zone in the Main Street area. The Ashton zone in the Main Street area appears to have been carried down so far by the fault movement that the oil did not go down to it, and it is not productive. The beds in the Main Street area are thought to be slightly arched. They are cut off on the southwest by a fault which passes through the Huntington Beach Elementary Schools group of buildings, and this fault is therefore called the Elementary Schools fault. This fault is marked on the surface by a line of low hills, very much as the High School fault is. The surface expression of these faults indicates that movement has taken place along them in very late geologic time, perhaps even in recent or historical time. As the surface indication of the High School fault is almost directly above the line along which the fault is found in depth by the oil wells, it can be concluded that the plane of the fault stands nearly vertical. The Elementary Schools fault is less well known than the High School fault because few wells have been drilled near it. The two faults are thought to be similar, but the Elementary Schools fault probably has the smaller displacement, both being offset down on the southwest side.

Reports state that the top of the Bolsa zones lies 2,000–2,200 feet below sea-level at the highest part of the structure; that the Upper Bolsa is about 160 feet thick and its oil ranges from 14° to 15.5° Bé. gravity; that the next 180 feet of section is wet and unproductive and separates the Upper from the Lower Bolsa. The Lower Bolsa is confined to a thickness of about 160 feet, its production ranges from 18° to 19.5° Bé. gravity, and below this zone no commercial production has been developed.

TOWNSITE-BARLEY FIELD AREA (INCLUDING SURF AREA)

The next block on the southwest contains two areas, known as the Townsite and the Barley Field, and probably also includes a third small group of producing wells known as the Surf area. The structure of the formations in this block, as for the others already described, has been worked out and published by representatives of the Califor-

nia State Mining Bureau. They have prepared structure contour maps showing that the beds in the Barley Field dip northeast as in the Old Field area; but in the Townsite area they swing around so as to dip eastward. The swing or curvature of these beds suggests that it may represent the plunging end of the axis or nose of an anticline; and a similar curvature in the beds of the Main Street and Old Field blocks aligned to the east, including the highest part of the Old Field block, suggests that all of these curvatures are related to a single axis which has been greatly obscured by faulting. The highest part of this structure is in the Townsite-Barley Field block near the western corner of the Townsite area. At that place the structure is interrupted by another fault, which approximately underlies Walnut Street, but curves oceanward toward the southeast.

The first important sands encountered by wells in the Townsite-Barley Field block are known as the Tar zone. This zone is practically continuous over the whole block, but production from it is not now of very much importance. The top of this zone lies at a depth of about 1,350 feet in the southwestern corner of the Townsite, from which it dips east and northeast to a depth of 2,000 feet or more at the northern edge of the block. In depth it comes to the Elementary Schools fault approximately opposite the Bolsa zone in the Main Street area, and it may have derived its oil by migration across the fault from the latter. It is likely, however, that these upper sands in which the oil occurs in these two areas are not the same strata, for the two divisions of this Upper or Bolsa oil zone are much closer together in the Townsite-Barley Field area than they are in the Main Street area. The next deeper important oil sand in the Townsite area is known as the Jones sand. Below it is an interval of less productivity and then a lower oil zone, which is the most important producing zone in the field. The Jones sand and the lower zone are the probable equivalents of the upper and lower Ashton of the Old Field area. The production in these zones has been greatest in the highest part of the structure near the Walnut Street fault, and has decreased rapidly down the dip toward the east and toward the Elementary Schools fault, so that much of the oil section is now flooded by edge waters which have advanced from the north and east. It is understood that at first no water existed in this area between the top of the Jones sand and the bottom of the lower zone. The Jones sand is now wet in a large part of the area and edge waters have encroached to a considerable extent throughout the middle zone and in the top 100 feet of the lower zone.

The thickness of the productive sands in the Tar zone is apparently very variable, but is shown in the Mining Bureau report to be

from 200 feet to perhaps 300 feet or more. The oil produced was generally 13.5°–15.5° Bé. in gravity. Beneath the Tar zone is about 1,050 feet of unproductive strata extending to the top of the Jones sand. The Jones sand zone is about 200 feet thick and produced 18°–19.5° Bé. gravity oil in the higher portion of the structure. The next 500 feet of strata, constituting a middle zone, has produced 21°–24° Bé. gravity oil. The next 500 feet below this is the lower zone, which has been the most productive in the area, and has the greatest areal extent of any of the zones. Its production varies from 24° to 28° Bé. gravity oil. Bottom water has been encountered beneath this zone in parts of the area, but it appears now that important deeper production may exist along the high parts of the structure bordering the coast.

In the Barley Field area northwest of the Townsite, only the deep zone, known as the Barley Field zone, is productive. This is encountered at a depth of about 3,700 feet in the higher parts of the structure and is apparently equivalent to the lower zone of the Townsite area, although the section is said to contain less sand than the latter. The Barley Field zone is rated as about 700 feet thick and produces 25.8°–28.4° Bé. gravity oil, according to reports. As contoured by the State Mining Bureau, the Barley Field joins with the Townsite area in the form of approximately a half dome with long axis near the coast and extending inland. This is discussed in further detail in the following paragraphs.

A few producing wells in the extreme southeastern part of the Huntington Beach field known as the Surf area probably belong to the Barley Field-Townsite structural block, although they may be more or less separated from the rest by subsidiary faulting. These wells obtain production from the deep zone which is there encountered at a depth of about 4,200 feet and yields oil of 22°–23° Bé. gravity.

TIDELANDS AREA

The Huntington Beach oil field has long been, and is still, known to geologists as probably the least understood of the oil fields of the Los Angeles Basin, the difficulty being with the complexity of the structure, the variability of the thickness and character of the sands and shale beds, and the lack or inaccuracy of the data obtained from the wells. Practically all the reports on the area make specific mention of this condition. Most of what has been described in the foregoing statement is accepted by geologists as true, although, of course, there are a number of points still subject to modification. On the other hand, practically nothing is known about the underground structure of the fourth and last block on the southwest, namely, the Tidelands

area. Even the Walnut Street fault, which separates this block from the Townsite-Barley Field block, still presents a number of unsolved problems.

The position of the Walnut Street fault as mapped by the California State Mining Bureau is said to be well determined by the recognizable differences in the formations encountered by wells on the southwest side of it. The Mining Bureau report shows the southwest side of it downthrown, as is the case with the other faults in the field; but at least one well-known geologist thinks the southwest side has been relatively uplifted. There is a surface exposure of what appears to be this fault in the embankment facing the tidal flat northwest of the Barley Field and about 400 feet north along this embankment from Ocean Avenue. At this place conglomeratic sandy beds on the north side of an apparent fault abut against sandy marls and shales on the south side. Both deposits belong to the superficial or late Pleistocene series. Although the beds on the north side are less consolidated and therefore look younger, there is an exposure in the embankment a little farther north which shows beds such as occur on the south side of the fault overlying the conglomeratic sandstone. Hence, the preponderance of evidence indicates that the southwest side of the fault was relatively, but possibly not greatly, downpressed.

The Mining Bureau reports show the tar sand of the Townsite area extending uninterruptedly across the Walnut Street fault; and, because the lower sands are interrupted by the fault, it is concluded that the lower beds do not conform to the structure of the upper beds; that is, it is stated that there is an unconformity between the lower zone and the overlying series. The evidence presented, however, does not show this to be the case. The oil of the Tar zone in the Townsite area could have migrated across the fault into a different sand on the Tidelands side, giving a false appearance of continuity of these beds. If movement along the fault has occurred at such a late date as to offset the much younger, superficial beds exposed in the embankment northwest of the Barley Field, it must also have offset all the older beds, including the sand containing the tar in the Townsite and Barley Field areas. Hence, the fact observed by the Mining Bureau that the tar or heavy oil is found at approximately the same depths on the two sides of the fault indicates that it does not occur in the same beds on the southwest side of the fault as on the northeast side. Apparently the evidence now available does not show the amount of offset that has taken place along the fault, nor determine the conformity of the upper and lower beds. It is not even certain in which direction the movement producing the offset took place. The greater productivity

of the wells on the southwest side of the fault could be explained by assuming that the source of the deep oil in this part of the field was on the southwest, and that its migration northeastward into the Townsite-Barley Field block has been impeded by the Walnut Street fault.

There are several reasons for believing that only part of the Huntington Beach oil field is situated on the land. The part of the field now known is structurally a half dome complicated by faulting, the other

FIG. 4.—Aerial photograph showing Tidelands area opposite Barley Field and Townsite areas.

half presumably being off shore. Not enough data are yet available to show whether the formations in the Tidelands block continue to rise southwest or whether at the foot of Fourteenth Street or Fifteenth Street or elsewhere they may not already be across the axis and on the southwest flank of the anticline. The contours shown on the Mining Bureau map are broken in this area along the coast because the form shown was recognized by the authors of the map to be almost certainly incorrect. The main production in the Tidelands block is in the lower zone, as it is in the Townsite-Barley Field block, and it is

true that the particular geologic formation (Miocene) in which this production occurs has a characteristic tendency to be thrown into complicated minor folds and small faults where adjoining beds are not so affected; but it is not possible to work out correctly the form of such minor variations without many accurate observations, and as the major structure is of first importance, it is usually not worth while to try to determine the minor structures.

Another important bit of evidence is available which indicates strongly that the axis of the dome is just a little off shore and roughly parallel with the coast. Airplane photographs (Fig. 4), taken when the water was clear and relatively quiet, show a dark patch in the water about half a mile off the coast opposite the end of Thirty-Eighth Street. This is undoubtedly a rock ledge on which kelp is growing, which statement is supported by the direct testimony of fishermen and lobstermen familiar with these waters. The rock is said to be sandstone occasionally exposed in part at extremely low tides. The larger patch shown by the photographs is much elongated parallel with the coast and has a more distinct limit that is concave on the northeast side. There is also a smaller patch southeast of the main patch (which is the one sometimes exposed at low tide) where the continuation of the sandstone outcrop on the same curvature shown by the inner side of the larger patch might be expected. This curvature indicates that this ledge is on the south side of a domal uplift along the anticlinal axis.

There is a third reason for believing that the axis of the anticline is just off the coast. The Main Street block in the Huntington Beach field is so situated that oil migrating in the Ashton zone up the dip from an inland source, after passing through the Old Field block, is deflected into the Bolsa and Tar zones above the Ashton. Apparently none of it remained or went down into the deeply depressed sands in the Main Street block, which correspond with the Ashton zones of the other blocks. This would effectively prevent the migration of oil from an inland source to the deep zone of the Townsite-Barley Field and Tidelands blocks. Hence, it seems that the oil must have migrated into these deep zones of the Townsite, Barley Field, and Tidelands areas from a source off shore, by following up the southwest flank of the anticline and crossing over the axis. In doing so, it would not be so likely to go down the northeast flank of the anticline as to remain mostly on top. The fact that production in the Townsite and Barley Field areas declines rapidly in northerly directions down the dip is in support of this view. This abrupt decline is similar to the decline observed in the Bolsa zone of the Old Field area down the dip away

from the High School fault, from which the oil of that zone probably came.

Thus there are three reasons for believing that the axis of the main anticline or dome of the Huntington Beach field lies just off the coast at the foot of Thirty-Eighth Street: (1) the general half-dome structure of the known part of the field; (2) the evidence of the location of the south flank afforded by the air photos; and (3) the probability that the oil in the deep zones of the Tidelands and Townsite-Barley Field blocks came from a seaward source over a near-by axis. It remains to be considered whether this axis off shore opposite the foot of Thirty-Eighth Street, or a branch of that axis, might in continuation reach the shore anywhere in the vicinity of Huntington Beach. It is likely that any wells drilled on or near the axis would yield the highest production, and that in a row of wells along the beach those having the maximum production would mark the crest of any anticline that might be present, especially if the production of the other wells in the row shows a regular decline in both directions away from the maximum. Initial production records such as are published when wells are brought in do indicate that the Standard Oil Company's Pacific Electric lease wells reach a maximum at wells Nos. 1, 3, and 16 and decline regularly southeastward to No. 15, the farthest away, and that they also decline, but less regularly, in the opposite direction from this central group.

It appears, therefore, that some kind of an axis or structure comes ashore at or near these Pacific Electric wells. This may be the plunging main axis of the whole field, or it may be a subsidiary axis or nose of structure branching from the main structure. In any case, if the high point of the dome is about a quarter mile off the coast from the foot of Thirty-Eighth Street, the axis at well No. 3 would be plunging east-southeastward. This same axis is indicated on the structure-contour maps of the Mining Bureau, continuing practically due eastward in both the tar zone and the deep zone of the Townsite area, and although obscured by faulting, it appears to have affected also the structure of the Main Street and Old Field blocks. The existence and the position of this axis are therefore pretty well determined by observed geologic facts.

As nearly as can be judged, the crest of this structural axis should extend along or near Ocean Avenue from the southwestern corner of the Townsite southeastward unless there are other complicating factors. The Walnut Street fault does, however, introduce a complicating factor. At least one well which is believed to have drilled through the fault indicates that the fault is not exactly vertical. It slopes slightly

southwest. Production from the ocean side of this fault along the crest of the main structural axis of the Huntington Beach field may reasonably be expected to be the largest and most important developed in the whole area.

SOURCES OF DATA

The main sources of information on the geology of the Huntington Beach area are in the published reports of the California State Mining Bureau, including the following references.

1. R. E. Collom, "The Huntington Beach Oil Field," *Summary of Operations*, Vol. 7, No. 5 (November, 1921), pp. 5–7.
2. J. B. Case, "Report on Huntington Beach Oil Field, Orange County, California, with Special Reference to Lack of Definite Subsurface Information after Eighteen Months of Drilling Activity," *ibid.*, pp. 8–42.
3. J. B. Case and V. H. Wilhelm, "Report on Huntington Beach Oil Field," *ibid.*, Vol. 9, No. 6 (December, 1923), pp. 5–16.
4. M. A. Grizzle, "Geochemical Relationship of Waters Encountered in the Huntington Beach Field," *ibid.*, pp. 17–28.
5. V. H. Wilhelm, "Methods of Determining the Fluid Content of Formations in Open Hole at Huntington Beach Oil Field," *ibid.*, Vol. 9, No. 9 (March, 1924), pp. 5–9.
6. F. A. Graser, "Recent Developments in the Huntington Beach Oil Field," *ibid.*, Vol. 12, No. 12 (June, 1927), pp. 5–16.
7. S. G. Dolman, "Tar Sands in the Townlot Area of Huntington Beach Oil Field," *ibid.*, Vol. 13, No. 12 (June, 1928), pp. 5–16.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 18, NO. 3 (MARCH, 1934), PP. 343-357

FACTORS GOVERNING ESTIMATION OF RECOVERABLE OIL RESERVES IN SAND FIELDS[1]

O. L. BRACE[2]
Houston, Texas

ABSTRACT

There are two ordinarily acceptable means of approach to the problem of estimating oil reserves: decline curves and the "volumetric" method. The former has had the field of its effectiveness reduced by the artificial production methods created by proration.

Of the many "volumetric" factors bearing upon this problem, the basic ones, (1) thickness and character of reservoir rocks, (2) porosity and degree of saturation, (3) contained gases, (4) temperature, and (5) contained moisture, relate to the quantities of original oil within the reservoir. Each of these presents difficulties of interpretation, and errors, if cumulative, may account for the discrepancy between a high initial estimate and a low actual recovery.

Proration, because it greatly prolongs a stage comparable with the "flush" period in older fields, encourages a growing tendency to overestimate the reserves of oil in new fields. This tendency may be partially overcome by a more thorough analysis of those factors employed in such appraisals and by a recognition of the artificial character of the conditions governing production today.

It has become the practice to give to "recoverable oil percentages" a definite value, but, without an exact knowledge of the amounts of original oil, it is obvious that this factor is an approximation, at best. Whether or not the value of this percentage is predictable, it is probable that the influence of certain aids to recovery, such as the "water drive," has been much exaggerated.

The writer offers no fool-proof method of overcoming the difficulties inherent in this problem but calls attention to the harmful effects of overestimation and suggests a recognition of all of the factors having a bearing on such calculations and the adoption of a more conservative attitude toward their evaluation.

INTRODUCTION

The solution of the problems involved in the estimation of recoverable oil reserves belongs essentially to the geologist. Of the factors upon which such calculations depend, the most important are those dealing with the lithology and texture of the reservoir rocks and, at last analysis, all other factors are of secondary importance in comparison with those of sand thickness and sand character. Without a thorough understanding of these questions, an intimate knowledge of the other factors bearing upon the problem is of little aid in arriving at a true picture of reserves.

A consideration of the technical literature of the past decade indi-

[1] Manuscript received, January 2, 1934.

[2] Consulting geologist, 2104 Bissonett Street. The writer wishes to make acknowledgment to L. C. Snider for valuable assistance rendered in the preparation of this paper and for constructive criticism of the completed manuscript.

cates that serious study of this problem has gradually passed from the geologist to the petroleum engineer, resulting in concentrating attention upon the secondary factors bearing on the mechanics of recovery and away from the primary one of lithologic reservoir characteristics. In this period, the subject has been touched upon in numerous geological field reports, but the question of recovery is ordinarily treated as a secondary issue and is dismissed with a casual statement as to the probable per acre yield, without supporting data of a technical nature. In other words, the geologist, while continuing steadily to improve his knowledge of structural interpretation leading to the discovery of new fields, seems to have been satisfied, after discovery, to make a broad guess as to the quantities of recoverable oil to be anticipated from the new areas which his efforts have brought to light.

During the past 10 years there has been a distinct change in the attitude of the oil industry toward the question of reserves. Undeniably, with the unstable economic conditions of to-day, this problem is of utmost importance. In the pre-war period, interest was centered in the possibility of an early exhaustion of our main oil resources, with little concern for the day-to-day relation between production and consumption. In that period, tremendous quantities of surface storage oil were in the process of accumulation and excess production was run to storage with little effect upon market conditions. At about the time the storage of oil was progressing up to and beyond economic limits, the industry entered a phase in which improved methods of scientific exploration and deeper drilling made available vastly greater supplies of oil than could be immediately utilized. These revolutionary discoveries served to push back the old fear of an early exhaustion of resources, submerging it beneath the problems created by a day-to-day flooded market. Proration was seemingly an unavoidable product of such a situation, and it was with proration that the practice of estimating reserves developed into a problem of critical importance.

It can safely be said that proration has fostered a tendency to overestimate the potentiality of new fields. The causes back of this tendency are largely psychological and arise from the unnatural conditions governing present-day production. Fields that are developed under a system of very limited output, tend to build up an illusion of high potentiality that is not borne out by a rational study of reservoir conditions.

Although there has been less serious consideration of this problem in the geological literature of recent years than the importance of the subject justifies, much prediction as to the capabilities of new fields

has appeared in the press and in trade journals. Upon the discovery of each new major field, early estimates on ultimate recovery are broadcast through the media already mentioned or through verbal discussion and, in many instances, have produced exaggerated ideas as to the true importance of fields. The difficulties into which a false viewpoint toward this question may lead us are readily brought out by a consideration of the present economic position of the oil industry. Most of the difficulties with which it has been beset in recent years may be traced to an apparent oversupply of oil. While there has unquestionably existed a day-to-day oversupply, partially due to the fact that it is no longer economically feasible to run overproduction to storage, this industry differs from many other basic industries in that the reserves upon which its existence depends are exhaustible and irreplaceable. The day-to-day supply, therefore, should be of secondary importance to the question of future supplies and it is in this sense that a faulty estimation of such reserves can create a viewpoint that may seriously undermine the stability of the industry.

It is not the purpose of this writer to criticize the geologist, past or present, for his apparent failure to recognize the paramount importance of this problem in its bearing upon the future of the industry. It is, rather, desired to discuss, in a non-technical manner, the factors involved in the calculation of reserves and to draw attention to the high factor of error lying, unavoidably, at the foundation of the most conscientious appraisal. Possibly, in this way, further discussion of a more technical nature may be encouraged and may lead ultimately to the widespread adoption of a more cautious attitude toward the premature application of these principles of analysis.

PRIMARY FACTORS

There are two ordinarily acceptable methods of estimating the quantity of oil trapped within a given reservoir: decline curves and "volumetric" analysis. The two methods approach the problem from different angles and at different stages. Decline curves have as a basis the data furnished by production performance and they can not be made to function in a given area until development has reached a stage of considerable advancement. "Volumetric" study, however, primarily requires a knowledge of the physical conditions characterizing the reservoir rocks and is ordinarily to be applied in the early stages of development. A basic difference in the operation of the two methods is that decline curves deal only with recoverable oil, while "volumetric" study concerns itself mainly with reservoir capacity.

In the pre-war period, decline curves supplanted an earlier use of

the "volumetric" method because of the greater accuracy of the resulting estimates. At that time, the impracticability of applying the decline-curve method to fields during their early or "flush" stage was not considered an important defect. The advent of proration, however, has forced a discontinuance of their use excepting in the case of pumping fields. Such curves, constructed from the natural producing ability of groups of wells, have quite manifestly had their usefulness in new fields destroyed by the artificial conditions created by present-day methods, because these methods tend greatly to prolong a stage comparable with the "flush" stage in the older fields.

RESERVOIR CAPACITY

Most of the estimates of visible petroleum reserves made within the past decade have resulted from an application of "volumetric" study. Theoretically, this method takes no cognizance of producing performance and proration should have had no bearing upon its effectiveness. Its use involves the coördination of several factors, the most important of which are: (1) thickness and character of reservoir rocks, (2) porosity and degree of saturation, (3) contained gases, (4) temperature, and (5) contained moisture. Each of these has a direct bearing upon the quantity of oil contained within the reservoir and, consequently, upon the quantity that may be removed from it. The difficulties that surround a sound appraisal of these factors can easily lead to errors of judgment which, if cumulative, may account for the discrepancy between a large initial estimate and a small actual recovery.

Sand thickness and character.—Under the most ideal conditions of development, a thorough knowledge of sand conditions is necessarily impossible. After a discovery is made, indicating the presence of a new pool, drilling usually progresses with caution, new locations radiating out from the discovery well. The completion of inside wells is carried out with only a partial penetration of the sand because of uncertainty as to the position of bottom water. Until the edges of the pool have been found, the sand section is, therefore, not entirely explored. Ordinarily, the general characteristics of the productive section are known through scattered dry tests drilled prior to discovery, but there are few instances where these may be accepted as direct evidence bearing on the area in which oil has been trapped.

During the initial stages of development, the sand section below the casing seat is thoroughly cored and the material thus recovered and brought to the surface constitutes the basis of our knowledge of the physical characteristics of the reservoir rocks. In most fields it is

not the practice to continue coring after the outlines of the pool have been determined, or at least after the initial wells have been completed on individual leases, since at this time the position of the casing seat is definitely established. Future wells are drilled prescribed depths into the "pay" and completed.

The technique of coring has materially advanced within the past few years, but, despite the improvement, recovery is still far from perfect and it is seldom that a well is completed without at least one major gap occurring in the record of the producing zone. In areas where the productive series is badly broken, it commonly happens that the records are rendered useless for detailed examination by the frequency of missed cores. This is particularly true of the Cretaceous and Tertiary fields of the Coastal Plain, where the relationship between the sand and shale layers that make up the productive zone is extremely variable both laterally and vertically. Coring in these areas is seldom more than 50 per cent efficient and, where most in need of reliable data, the investigator is often thrown back upon the resources of his imagination. His only alternative is to accept the interpretation of the driller, which, it has been proved, is of little value for his purposes. In most fields the percentage of good sand, according to drilling records, increases with the decrease in the effectiveness of core recovery. Inversely, many of the poorest sand sections encountered are logged where core recovery has been most nearly perfect.

As stated, it is normal field practice to core the productive zone in newly developed areas in only the key wells. In most sand fields, the lithologic character of the "pay" horizon varies greatly from well to well so that with perfect core recovery in these key wells, detailed information regarding sand characteristics would still leave much to be desired. Add to this the further uncertainties offered by the normally poor recovery in the key wells and a result is obtained in which imagination occupies a position of major influence. In absence of definite facts upon which to base opinion, there is created an almost universal tendency to exaggerate the quantity and quality of saturated sand.

It is evident that the very considerable latitude at the command of the investigator in interpreting these essential data necessitates the exercise of much caution in formulating estimates of reservoir capacity. In instances where there exists a combination of large area and highly variable reservoir lithology, errors approximating 35–50 per cent may possibly be carried into the calculation of capacity, so that failure to apply a reasonable correction factor renders such determinations worse than useless. In those major fields that have recently

reached the peak of production, there is evidence in the present indicated recovery to suggest that in nearly every case this correction factor was neglected in arriving at the early estimates. Further, the fact that most estimates were considerably above the indicated recovery, suggests conclusively a general tendency to give to questionable data the most favorable interpretation possible.

Porosity and saturation.—In dealing with recovery problems, we are first concerned with reservoir capacity. This capacity, assuming that thickness is known, is a question of the ability of a sand to store oil and depends on the percentage of voids between sand grains. The fundamental difficulties attending an accurate appraisal of sand thickness and lithologic character are carried progressively forward into a consideration of porosity. An understanding of each of these characteristics depends on visual examination of the entire sand section, without which, conclusions must be regarded as approximations, with a factor of error of unknown quantity.

Recognized productive reservoir beds are usually typified by wide variation in the lithologic character of the included section and, within the sands themselves, by a wide range in sand grain size and in percentage of voids. This is true whether we are dealing with the Bradford sand of Pennsylvania, the Woodbine or Cockfield of Texas, the Bartlesville of Oklahoma, or the Wall Creek of Wyoming. In many instances, where complete core recovery has been possible, voids have been found to range from a minimum of one per cent to a maximum of 30 per cent in the same saturated zone.

The Woodbine sand series of East Texas shows an infinite variability in both composition and porosity. The sands, normally to be classed as productive, vary from hard sandstones to impure sands in which the sand-grain interstices are largely filled with silt and volcanic ash, and to coarse-grained quartz sands with a maximum percentage of voids. All of this material may show saturation.

It has been stated that, under normal field operation, only a small part of the sand section is made available to the investigator for visual inspection. If this statement is acceptable, then it must be admitted that any conclusion as to average porosities is necessarily based on very unsatisfactory data. If a piece of sand is selected from a core and subjected to porosity tests, the resulting figures are of little significance in their relation to the average porosity for the entire sand section. As a matter of fact, they are as far from acceptable as are the statements of the average driller regarding the amount of saturated sand penetrated in the course of well completion.

Experiments by the United States Geological Survey and the

United States Bureau of Mines show that initial yield and ultimate recovery increase rapidly in relation to increases in porosity. These experiments, carried out by Melcher,[3] also show that, regardless of saturation, sands with voids falling below a minimum of 10–12 per cent will ordinarily not yield oil in commercial quantities. In the Burbank field of Oklahoma, the lower productive limit of porosity, according to this investigator, is 13 per cent. Some of the Bartlesville sand fields show a lower limit of 12 per cent, while Burkburnett and Salt Creek show limits as low as 10.5 per cent.

The significance of such findings should not be underestimated. In the cores recovered from type fields such as Oklahoma City, East Texas, and Conroe, it is known that there are saturated sands of favorable appearance in which porosities fall below these indicated minima and there are instances where sands, in which voids comprise more than 25 per cent of the whole, occur only as relatively thin strata. The sands interbedded with these more favorable layers and making up the remainder of the section have represented all degrees of porosity between lower and upper limits.

United States Geological Survey experiments with the Bradford sand of Pennsylvania show a range of void percentages in the saturated zone extending from a low of 1.4 to a high of 17.3. In one sand section of 62 feet, there was only 29 feet with porosities greater than 10 per cent, although all of the 62-foot section showed saturation. In the fields of the Mid-Continent, it is improbable that such detailed pore-space study has been carried out in many complete sand sections. This is to be explained by the more difficult coring problems presented by the variation in hardness and lithology of the strata comprising the "pay" zones and by the lack of an incentive, such as exists in the Appalachian region, to justify the increased expenditures which such practices require.

In the East Texas field, some porosity data have been made available, but these cover only thin sections of the higher grade sands. As a consequence, the results are of little significance or value. The core log of one of these wells, in which the detailed description is sufficiently suggestive to furnish a picture of both lithology and porosity, is given here. This well is the Stanolind-Laird No. 6, I. Ruddle Survey, Gregg County, located in the approximate center of the field. Core recovery in this well was almost 100 per cent.

These cores cover a total of 81 feet of "pay" section, 48.5 feet of which is sand of varying degrees of purity. Thirty feet of this sand

[3] A. F. Melcher, "Texture of Oil Sands with Relation to Production of Oil," *Bull. Amer. Assoc. Petrol. Geol.* Vol. 8 (1924), pp. 768–69.

shows saturation, but no data are available to indicate what part of this might be expected to carry porosities of 25 per cent or over. It is probable that such percentages would range from as low as 5 per cent to as high as 30 per cent, with an average of 15–20 per cent. Attention is called to the high ratio of argillaceous material in the section and to

Depth, Feet	*Formation*
3,648.5	Base Austin chalk
3,650	Cap rock
3,664	Sand, medium coarse, saturated
3,665	Sand, dry, silty
3,667	Shale, lignitic
3,668	Sand, fine, silty
3,670.5	Sand, fine, slight saturation
3,671	Sand, silty
3,673	Shale, black
3,681	Sand, fine silty, dry
3,682	Sand, fine silty, slight saturation
3,684.5	Shale, black
3,686	Sand, fine silty, dry
3,691	Shale, black
3,691.5	Sand, coarse, saturated
3,693	Shale, black
3,694	Sand, coarse, saturated
3,695	Sand, dry
3,697	Sand, coarse, saturated
3,698	Shale, black
3,698.5	Sand, saturated
3,699.5	Sand, silty, dry
3,701	Shale, black
3,702.5	Sand, saturated
3,704	Shale, black
3,705	Sand, saturated
3,706	Shale, black
3,707	Sand, saturated
3,716	Shale, black
3,717	Sand, hard, fine, dry
3,718	Shale, black
3,718.5	Sand, saturated
3,722	Shale, black, sandy
3,723	Sand, lignitic, saturated
3,724	Shale, black
3,725	Sand, silty, dry
3,728	Shale, black
3,730	Sand, fine, dry
3,730.5	Sand, coarse, saturated
3,731	Shale, black

the fact that, of the 48.5 feet of sand present, 18.5 feet is too tightly cemented to show any trace of saturation. It should be added that this core record, according to the observation of the writer, is more or less typical of East Texas sand conditions.

It might be possible to proceed with a description of core records from type Cretaceous and Tertiary fields of the Coastal Plain and from the Paleozoic fields of Oklahoma, but it is believed that the purposes of this paper have been served by the porosity data so far

presented. The significant point it is aimed to stress is that there is no such thing as uniformity in the porosity of any of our known productive sand horizons and the variation in such percentages from which averages must be drawn are not readily predictable. In cases where recovery has permitted porosity tests on full sand sections, an almost complete range of voids has been found. Although it is frequently the practice to utilize samples of only the best sands as a basis for porosity determinations, it is obvious that within this normal range, the upper limits, with voids of 25 per cent or greater, are of no more importance than are the lower limits, in which voids of less than 10 per cent predominate. An average, therefore, produces a figure falling considerably below the one ordinarily used as a basis for reaching reservoir-capacity estimates and, in working with variable sand sections of any considerable thickness, it is necessary that this downward correction be made, if the result is to approximate actuality.

DEDUCTIONS FOR SHRINKAGE

Gases and temperature.—The bearing of reservoir gases upon the estimation of recoverable oil is twofold. Gases, because of their expansive power, tend to reduce the oil capacity of reservoirs and, through the same property, to facilitate recovery. Increased temperatures, like gases, serve to expand the oil and thereby to reduce reservoir capacity. Due to the similarity in the results produced by their functioning, these two factors are considered together.

In a reservoir, gases occur in three forms: (1) as an integral part of the oil, in which case they are dissolved in it and serve to increase the bulk of the oil body and to lower its viscosity; (2) in a miscible relationship with the oil; that is, disseminated throughout the oil body as a gas; and (3) as a separate and distinct gas body in the higher reaches of the reservoir. In the first two forms, gas has a very profound bearing upon reservoir capacity.

In ordinary practice, the terms "reservoir oil" and "recoverable oil" are misleading in that they are used to designate relative quantities of oil when brought to the surface. The distinction between oil in the reservoir and oil in the tanks is an important one because of the shrinkage that takes place through escape of gases and the reduction in temperature when oil is produced. The problem involved is somewhat as follows. In a given area, a study of sand thickness and porosity has led to acceptable conclusions as to reservoir capacity. It is then assumed that the reservoir contains so many barrels of oil per acre, of which a certain percentage is recoverable. In reality, since reference is made to reservoir oil in terms of surface oil, this conclu-

sion does not take account of the facts. Recent experiments by the United States Bureau of Mines indicate that the shrinkage occasioned by the escape of gases and by thermal contraction is a factor of great importance and that it must be given consideration.

In experimenting with East Texas oils, Lindsly[4] found that, under conditions approximating actual production practice, the shrinkage in volume of crude in the passage from reservoir to surface amounts to approximately 20 per cent. Of this, he attributes a loss of 3.5-4 per cent to thermal contraction and the remainder to liberation of dissolved gases. Explanation lies in the fact that, under increased pressures, oil shows an increasing affinity for gas and, by absorption, its bulk is enlarged and its viscosity lowered. Inversely, as pressures decline, this affinity is destroyed, gas is released, and shrinkage takes place, together with a proportionate rise in viscosity. Proof of this action is to be found in the variation in gravity of oil produced from well to well, this change being brought about by the loss or retention of the lighter gas fractions, resulting from variations in production practice. In the instance of this particular experiment, oil was released from original reservoir pressures of about 1,600 pounds, and a temperature drop from 146° F. in the reservoir to 90° F. at the surface was produced. In experiments with Kettleman Hills crude, Lindsly[5] found a shrinkage due to these same causes equivalent to 36 per cent. Here the pressure and temperature reductions were greater, due to the added depth to the reservoir rocks.

It is probable that the principle established as a result of these experiments may be considered to have a universal application in the estimation of reserves. Lindsly makes such an application in estimating that the approximately 262 million barrels of oil produced from the East Texas field at the time of his experiments, occupied a space in the reservoir equivalent to 327 million barrels. It is probable that this correction for shrinkage due to reduction in temperature and to escape of dissolved gases will approximate 25–30 per cent at Conroe and at Oklahoma City.

Moisture.—An additional factor having a bearing of probable importance on the estimation of reserves is that of contained moisture. Little consideration has been given to this subject in available literature, and statistical data are so meager that treatment here is brief.

Considering the processes of deposition, it has long been recog-

[4] Ben F. Lindsly, "Gas Solubility Study Conducted, etc.," *Oil and Gas Jour.* (June, 1933).

[5] *Idem*, "Preliminary Report Regarding Solubility of Natural Gas in Crude Oil," *Amer. Inst. Min. Met. Eng.*, New York meeting, February, 1931.

nized that connate waters tend to resist the replacement action of oil and gas. This is especially true of water occupying those finer interstices that constitute an appreciable percentage of the voids. Within a producing area, the fact that the produced oil is clean is no index as to the presence or absence of moisture in the sand, since the forces that held the water in place during oil migration would perform the same function during oil extraction.

Under circumstances which the writer is not at liberty to divulge, an organization performed experiments along this line in a Coastal field. In this field, early estimates, based on meager "volumetric" data, suggested a recovery of 17,500–20,000 barrels per acre. Actual production statistics lowered this estimate to a probable 7,000–10,000 barrels. In seeking an explanation for this discrepancy, sand cores were distilled and their fluid content analysed. Cores from the center of the field, where no water had appeared with production, were found to contain moisture to the extent of 16 per cent of the fluid.

As already stated, statistical data are too meager to permit extended discussion. The instance cited may be an isolated one and have little bearing on general conditions. The writer is inclined to think, however, that contained moisture is present in all fields and that it may constitute an important factor in some of them. There is one phase of the problem that may minimize its importance in the estimating of reserves. Since the retained moisture was not displaced by the incoming oil during migration, it obviously occupied, in the main, the finer void spaces in the reservoir rocks. It is possible, therefore, that moisture is largely confined to those zones where porosities fall below 10 per cent and from which no commercial oil may be anticipated, as suggested by the experiments of Melcher. This is a question that will require additional experimentation to clarify. As to the discrepancies between early estimates and actual recovery in the instance just noted, it is probable that partial explanation lies with the improper valuation of those other factors with which this paper is concerned.

RECOVERY PERCENTAGES

The mechanical process of oil recovery is accomplished through the agency of certain inherent forces confined within the reservoir. The rocks which serve as a trap for oil and gas lie at varying depths beneath the surface, and a differential between reservoir and surface pressures exists through the action of weight of overburden, expanded gases, and hydrostatic water head. When a reservoir is penetrated by the drill, oil is forced to the surface in an effort to equalize these

pressures and one or more of these forces acts throughout the life of the field to move oil toward the well mouth.

The most important of the agencies of recovery is gas. As already set out, gas occurs in oil reservoirs in a dissolved form, in a miscible form, and as a separate body. In each form it adds something to the ability of the oil to escape naturally from a pool. There is rather strong evidence to indicate that the influence of varying oil-gas ratios on ultimate recovery has been overemphasized. It is believed, rather, that the main influence of such variation is on the ratio of flowed oil to pumped oil, and not on ultimate yield. In other words, a field in which the oil is saturated with gas will in all probability flow a greater percentage of its recoverable oil than one in which there is a considerable undersaturation, but it is not so certain that it will show a greater ultimate percentage of recovery.

The second important factor in mechanical recovery is the so-called "water drive." For many years much stress has been placed upon the importance of this force, but there is now a rising tendency toward the belief that water encroachment has but a secondary influence upon ultimate recovery in sand fields. There is little doubt that as gas pressure within the reservoir approaches exhaustion, encroaching marginal and bottom water tends to render assistance by washing the sand and by adding bulk to the fluid entering the well, but in the flush stage its replacement action is ordinarily too slow to serve as an aid in maintaining flowing pressures. Water is supposed, according to popular theory, to act as a flushing agent by rushing into the sand and breaking down the cohesive forces set up between the sand grains and the oil, but this is true only in a strictly modified sense. As a matter of fact, the movement of water in the normal sand reservoir may more aptly be described as a percolation than as a drive. In advancing through the sand, it naturally follows those highly permeable strata from which oil has most readily moved and avoids those strata of low permeability which are most in need of a flushing medium, so that even though water entered the reservoir with considerable force, its action would in no sense be distributed over the whole sand body. It is logical to assume that the ultimate effect of an abundant and steady water encroachment upon a widespread sand body of uniform permeability would be to very materially increase oil recovery. Under conditions normally encountered, however, it is improbable that an active "water drive," as compared to a sluggish "water drive," would influence ultimate recovery by a margin to exceed 10–15 per cent.

The writer is unable to find much technical background for the

recoverable oil percentages applied in the ordinary estimate. The parts of this whole complex problem are so tied together that one depends upon the other for the ultimate solution. Of all the factors in this general equation, recoverable oil percentage has fewer qualities of its own on which to base conclusions. In ordinary practice, a pool estimated to contain 120 million barrels, and that has ultimately produced 48 million barrels, may be said to have shown a recovery of 40 per cent. Or, to reverse the process, with a recovery factor of 50 per cent and actual recovery of 50 million barrels, a reservoir is assumed to have contained initially 100 million barrels of oil. Unfortunately, in each of these cases, two of the essential factors are imaginative, entirely lacking in tangible background. An example of this method of reasoning may be cited from a paper by Snow,[6] in which he compares sand conditions and recovery in the Bartlesville sand pools of Oklahoma, with those in the East Texas field. It is stated that sand conditions are equally good in both areas; that the Bartlesville sand pools have averaged only 8,000 barrels per acre, representing only 15 per cent of the contained oil, and that this low recovery percentage is attributable to ineffective "water drive." It is further stated that exact figures as to thickness, porosity, and permeability of the oil-saturated portions of the Bartlesville sand are not available. On the basis of this last statement, it is obvious that the reservoir capacity of these pools is not known. Is it not possible, or even probable, that the amount of oil originally present has been overestimated and that the percentage of recovery, whether with effective "water drive" or not, has been greater than the estimates indicate? Surely, it can not be said with assurance that a field has produced a very low percentage of its original oil when the quantity of that oil is admittedly unknown.

CONCLUSIONS

The discussion of the factors involved in the estimating of reserves has been taken up in this paper primarily from the standpoint of their controversial character. The non-technical type of treatment bears witness that there has been no desire to advance a mathematical solution by which such calculations may be rendered fool-proof. As a matter of fact, the various factors that form a basis for this study offer such obstacles to accurate interpretation that it is improbable that such a solution could be devised. Because of these inherent difficulties, the best that may be hoped for is to promote improvements

[6] D. R. Snow: "Water Encroachment in Bartlesville Sand Pools, etc.," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 16, No. 9 (September, 1932), pp. 881–90.

whereby errors in evaluating the unknown quantities may be reduced to a minimum. At this time, such reductions can only be accomplished with great difficulty, but experience should serve as a guide toward eventually striking averages that will produce acceptable results.

There follows a recapitulation of the various factors that form the ground work for this problem.

1. In estimating thickness and character of reservoir beds, lack of opportunity for visual inspection leaves much to the imagination. General thickness of the productive zone may be deduced with fair accuracy, but character, particularly under conditions where lenticularity brings about rapid gradations in lithology, must depend for determination upon the meager acceptable data available.

2. Porosity figures, to be of value, must consist of detailed averages for the complete sand section. To secure these, an understanding of sand characteristics elsewhere must often be used to supplement the meager, but more significant, local data. Regardless of source, it is of paramount importance that the wide variation in porosity ratios typifying the normal saturated sand section should be recognized.

3. The influence of dissolved gases and temperature upon expansion of oil bulk is of positive character and readily measurable and allowance may be made for it with reasonable accuracy. Present experimental data suggest that nowhere may this factor be disregarded if results are to approximate actual conditions.

4. Included moisture constitutes an important but little understood factor bearing on the exact solution of these problems. Before a correction for its use may be generally applied, more experimentation must be carried out.

5. The question of recovery percentages hinges on that of reservoir capacity, since a statement as to the former presupposes an almost complete knowledge of the latter. Normally, the ratio of reservoir oil to recovered oil should vary but little from pool to pool. This common ratio, customarily established without recourse to technical reasoning, has, however, no satisfactory value.

In conclusion, it is desired once more to emphasize the necessity of recognizing the indeterminate quality of the most important of the factors which enter into a "volumetric" estimate of recoverable oil from a field. It will probably not be denied that there has been a general tendency to overestimate, through partial application of the "volumetric" method, the quantities of oil to be recovered from our recent pools during their "flush" stage; also it will probably not be

denied that this tendency results from the practice of giving the most favorable interpretation to all data where values are in doubt. There is a natural inclination to give to sands not available for visual inspection, the benefit of all questions involving saturation. Likewise, porosity determinations are most frequently made from samples which are of higher porosity than the average for the entire productive sand thickness, despite the common knowledge that sands of low porosities constitute an important part of the "pay" section. Unfortunately, errors in estimating productive sand thickness, porosity and saturation, are most likely to accumulate in the direction of overestimation of reservoir capacity, so that this tendency, plus a nonrecognition of shrinkage resulting from thermal contraction and loss of gas, has resulted, in many instances, in estimates that appear today to be exceeding actual recovery by 25–100 per cent. Although it must be admitted that the scaling down of these optimistic values can not be carried out without some risk, the common sense that arises from experience should guide the investigator nearer a fair approximation than the methods of the past have produced.

As a close to this paper, the question naturally arises, who benefits from an unreasonably optimistic estimate of recoverable reserves? Surely, neither the petroleum industry nor geologists as a group. From the standpoint of the industry, it is a positive necessity that a reasonable reserve be maintained as a guard against future demand and it is one of the important duties of the geologist to determine the size of such reserves so that the degree of this protection may be known with reasonable certainty at all times. Such a duty can not be fulfilled by maintaining a spirit of false optimism, based largely upon imaginative conclusions, but requires, rather, a conservative attitude in which both experience and common sense are prime factors.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 18, NO. 3 (MARCH, 1934), PP. 358-367

BASE EXCHANGE IN RELATION TO COMPOSITION OF CLAY WITH SPECIAL REFERENCE TO EFFECT OF SEA WATER[1]

W. P. KELLEY[2] AND G. F. LIEBIG, JR.
Riverside, California

ABSTRACT

The term "base exchange," as commonly used, refers to the alteration in cation composition of a solid resulting from treatment with a salt solution. Many minerals undergo cation exchange to some extent, certain types of clays being especially reactive in this regard. Treatment with ocean water produces notable cation exchange in clays.

Although sodium is the dominant base of ocean water, its magnesium plays a greater part in base exchange with clays than sodium. For example, soils recently submerged in ocean water and samples of soil and a bentonitic clay, after treatment with ocean water, have been found to contain somewhat more replaceable magnesium than replaceable sodium. On the other hand, Taylor and Case reported that clays, overlying oil deposits, contain little replaceable magnesium and relatively much replaceable sodium. These facts suggest that the oil-field clays have been in contact with salines quite different from ocean water. The composition of oil-field brines is in harmony with this conclusion. However, it is possible that the base-exchange constituents of the oil-field clays have undergone molecular re-arrangement or crystallization since being deposited in ocean water, with the result that the magnesium has passed into nonreplaceable forms.

INTRODUCTION

It is well established that various kinds of salt solutions react chemically with certain kinds of clays. This reaction is commonly referred to as base exchange. Strictly speaking, the reaction is cation exchange rather than base exchange. It denotes that more or less of the cations of the salt solution exchange places with some one or more of the cations that are held by the clay. Therefore, when a clay is treated with a salt solution, the chemical composition of both the salt solution and the clay becomes altered. If, for example, a solution of sodium chloride is shaken with a sample of ordinary clay, or if the solution is allowed to seep through a bed of the clay, a part of the sodium of the solution will replace more or less calcium or magnesium that was originally combined with or absorbed by the clay. The result will be the formation of what is now known as sodium clay. Conversely, the sodium chloride solution will lose some of its sodium and gain an equivalent amount of calcium or magnesium.

[1] Manuscript received, October 23, 1933.

[2] Citrus Experiment Station, University of California. Introduced by W. B. Wilson.

If calcium clay is treated with a solution of magnesium chloride, more or less of the calcium will likewise be replaced by magnesium, and if calcium clay is treated with a solution containing both sodium and magnesium salts, calcium will be replaced partly by sodium and partly by magnesium. In the last named case the relative extent to which sodium and magnesium take part in the reaction will be determined chiefly by the ratio of sodium to magnesium in the original solution. This cation-exchange reaction is usually found to be more or less completely reversible, which denotes that sodium or magnesium clay can be converted into calcium clay by simple treatment with a soluble calcium salt.

There are also many other substances of mineralogical and geological interest that are capable of undergoing more or less cation (base) exchange. For example, Lemberg (5)[3] showed that leucite can be converted into analcite by treating the former with a solution of sodium carbonate. This conversion of leucite into analcite involves base exchange quite analogous to that which the clays undergo. Another class of substances, whose base-exchange property is more generally recognized, is that of the natural zeolites. Moreover, Sullivan (9) and others have shown that a great many other complex silicates are capable of undergoing cation exchange to some extent.

Although many of the clay minerals that occur in the state of nature will react with salt solutions by cation exchange, not all clays possess this property. For example, kaolinite does not undergo cation exchange to any important extent, for the reason that kaolinite does not contain important amounts of replaceable bases of any kind. By replaceable bases we ordinarily mean calcium, magnesium, potassium, and sodium. The aluminium and iron of ordinary clays are not replaceable by the cations of ordinary salt solutions.

The natural clays differ in their content and in the kind of replaceable bases which they contain. Calcium is usually the dominant replaceable base of clays, but magnesium clays are found in certain deposits and certain beds of clays contain relatively much replaceable sodium. At least one of the clay minerals (Ordovician bentonite) contains considerable replaceable potassium.

There is good reason for the belief that sodium clays occur only in deposits that have been overrun by solutions of sodium salts. Briefly, this conclusion rests on two lines of evidence: (*a*) the properties of sodium clay; (*b*) the character of the deposits. Sodium clay is relatively unstable chemically. It is easily converted into hydrogen clay, calcium clay, or magnesium clay. A bed of sodium clay will be

[3] Numbers in parenthesis indicate references at end of article.

preserved for a long period as sodium clay only provided that it is so situated as to be protected from the action of solutions containing other cations. Even very dilute solutions of calcium salts, such as calcium bicarbonate, will gradually convert sodium clay into calcium clay.

When all of the different replaceable bases that are held by a given clay deposit have been replaced by one base, calcium for example, the clay is said to be saturated with that particular base. The total amount of replaceable bases that are held by a given clay is a fairly definite quantity and can be determined analytically.

The replacing power, or what is sometimes called the energy of replacement of the different metallic cations, differs widely. It is well established that calcium possesses high replacing power; magnesium stands next, followed by potassium and then by sodium. This means that sodium clay is relatively easily converted into calcium clay. All that is necessary to accomplish this conversion is to leach the sodium clay thoroughly with a dilute solution of some calcium salt. However, it is difficult to leach a bed of sodium clay with water because sodium clay is extremely impervious to water owing to the fact that it tends to be highly deflocculated. However, sodium clay is more or less pervious to dilute solutions of calcium salts.

Since waters of meteoric origin commonly contain more or less calcium bicarbonate, it is to be expected that sodium clays, upon being subjected to prolonged leaching in the state of nature, will become converted more or less completely into calcium clays. This is one reason why sodium clays are not more commonly found. There is, however, another and perhaps more important factor. Reference is made to the rôle played by calcium carbonate. If, for example, a sodium clay is interbedded with calcium carbonate, rain water falling directly on the deposit will dissolve more or less calcium carbonate and the calcium thus dissolved may ultimately convert the sodium clay into calcium clay. It appears that this conversion may take place without the mass assuming the granular structure of normal calcium clay. A full explanation of this fact can not now be given, but experimental evidence shows that calcium clay, after having been pronouncedly deflocculated by treatment with sodium salts, regains its granular structure extremely slowly. Therefore, the fact that a given clay is sticky and more or less impervious to water does not necessarily indicate that it contains sodium clay.

Calcium or hydrogen clays predominate in the soils of humid climates. On the other hand, sodium clays are found here and there in the soils of arid regions, owing to the action of soluble sodium salts

which accumulate in these soils. Investigations by the senior writer and his associates, now in process of publication, show that the sodium clays of alkali soils may be converted into calcium clays by leaching with water, provided calcium carbonate is a constituent of the soil.

A few years ago E. McKenzie Taylor (10, 11, 12) reported that the shales and clays overlying the oil deposits of several different oil fields contain sodium clay as their dominant constituent. Recently Case (1) verified this fact in studies on the shales of certain Oklahoma oil fields. Taylor holds that the marine origin of these deposits accounts for the fact that they contain sodium clay. As is well known, sodium chloride is the most abundant constituent of sea water. According to Taylor, the clays of oil-field deposits were acted upon by the sodium chloride of sea water during the period of submergence, with the consequent conversion of the normal calcium clays into sodium clays. On the other hand, Case has expressed some doubt about Taylor's hypothesis.

TABLE I

Replaceable Bases in Oil-Field Shales
(Expressed as milli-equivalents per 100 grams)

Reported by Taylor (10, 11, 12)			*Reported by Case (1)*		
Location	*Ca*	*Na*	*From Oklahoma Sample*	*Ca*	*Na*
Rumania					
Average of 4 samples	3.6	32.7	1	3.7	4.3
			2	4.5	11.5
West Indies					
Average of 6 samples	3.7	12.9	3	3.1	8.2
			4	3.8	11.8
Trinidad					
Average of 4 samples	2.4	28.6	5	4.0	15.5
			6	2.7	9.9
Mexico					
Average of 12 samples	3.7	46.1	7	1.6	4.2
			8	6.7	19.5
Alsace					
Average of 6 samples	1.7	22.1	9	3.7	15.6
			Average	3.8	11.2
Texas					
Average of 4 samples	5.1	17.6			
California					
Average of 9 samples	4.8	13.4			

In Table I are reported representative analyses of oil-field shales made by Taylor and Case. The data are expressed as milli-equivalents per 100 grams. They show that the content of sodium clay exceeds that of calcium clay in every sample that was studied. With certain samples, practically the only replaceable base found was sodium, which implies that almost all of the clay has been converted into

sodium clay. Taylor made no mention of the presence of magnesium clay in his samples, but Case stated that the amounts of replaceable magnesium in the Oklahoma samples were negligible.

In contrast to these oil-field clays, soils recently submerged by ocean water have been found to contain relatively much magnesium clay. Hissink (3) reported, for example, that the marine muds on the coast of Holland contain more replaceable magnesium than sodium (Table II). Page and Williams (6) investigated certain soils along the coast of England that had been submerged by sea water a short time previously owing to an excessively high tide. Their results agree very well with those of Hissink.

TABLE II

REPLACEABLE BASES OF SOILS AND CLAYS RECENTLY ACTED UPON BY SEA WATER
(Expressed as percentage of total replaceable bases)

	Ca	*Mg*	*K*	*Na*
Reported by Hissink (3)	24	49	8	19
Reported by Page and Williams (6)	47.9	26.0	5.5	20.6
Reported by Salgado (8)				
0–9 inches	85.0	10.8	3.5	0.7
9–18 "	84.4	11.9	2.5	1.1
18–30 "	75.4	20.1	2.4	2.1
30–42 "	71.6	23.4	2.5	2.5

The recent investigations of Salgado (8) are of special interest in this connection. He investigated certain clay soils and subsoils of England that have been derived from Jurassic and Cretaceous sediments of marine origin. None of these was found to contain important amounts of sodium clay, but significant amounts of replaceable magnesium were found in every sample, and it is especially interesting to note that the amount of replaceable magnesium increased markedly with depth. Since paleontological evidence shows that these deposits were laid down in sea water, it is certain that more or less sodium clay was formed during the submergence with sea water. The fact that sodium clay is not now an important constituent of these deposits strongly supports the statement made above, namely, that sodium clays are relatively unstable and easily converted into calcium clays by the action of meteoric waters. As is well known, more or less calcium carbonate is commonly deposited on the floor of the ocean. Marine deposits are likely, therefore, to contain more or less calcium carbonate, which, as stated already, is a potential source of calcium by which the sodium clays formed during the submergence may later become converted into calcium clays.

The fact that the replaceable bases of the oil-field clays appear to differ materially from those of soils recently submerged by sea water, prompted the authors to investigate this question. Two differ-

ent experiments were made. (*a*) A soil, the clay constituents of which have been under investigation in our laboratories for some time, was shaken with sea water obtained from the Pacific Ocean near Huntington Beach, California. The soil sample was then thrown on a filter and leached with fresh quantities of sea water until its clay constituents practically ceased to react with the sea water. The replaceable bases than held by the sample were determined. (*b*) A similar experiment was made with a sample of bentonitic clay from Otay, California. According to Ross and Shannon (7), this material is composed primarily of montmorillonite. It is exceedingly reactive from a base-exchange standpoint. Before beginning the experiment, the bentonitic clay was converted into calcium clay by prolonged leaching with a solution of calcium chloride. The sample was first shaken with a considerable volume of sea water and then was leached with sea water for several days, after which the replaceable bases of the sample were determined. The results are shown in Table III.

TABLE III

EFFECT OF SEA WATER ON SOIL AND CLAY

	Milli-equivalents per 100 grams				*Percentage of Total*			
	Ca	*Mg*	*K*	*Na*	*Ca*	*Mg*	*K*	*Na*
				Soil				
Before treatment	21.70	6.00	1.36	1.22	71.7	19.8	4.5	4.0
After treatment	6.05	11.04	1.98	10.72	20.3	37.1	6.7	35.9
				Bentonitic Clay				
Before treatment	106.0	0	0	0	100.0	0	0	0
After treatment	10.85	48.35	6.90	39.13	10.3	45.9	6.6	37.2

It will be noted that both the soil and the bentonitic clay were affected by sea water similarly. However, one important difference will be noted. The bentonitic clay was much more completely altered by the sea water than the soil. The samples, after treatment, were found to contain replaceable calcium and sodium in ratios similar to those found by Taylor in some of his oil-field shales. It will also be noted that the replaceable potassium of both the soil and the bentonitic clay was increased somewhat by treatment with sea water. Finally, both samples were found to contain greater amounts of replaceable magnesium than of replaceable sodium after the treatment with sea water. Our results with soil suggest that the material which Hissink studied had reached approximate equilibrium with sea water.

After these experiments had been completed, several samples of Oklahoma oil-field shales were kindly sent to us by L. C. Case, of Tulsa, Oklahoma. These have been treated with sea water in the same way as were the samples of soil and bentonite. After the treatment

the average content of replaceable bases, expressed as milli-equivalents per 100 grams, was found to be as follows: *Ca*, 2.69; *Mg*, 6.24; and *Na*, 5.74. Expressing these data as percentage of the total replaceable bases, we find $Ca = 18$, $Mg = 43$, $Na = 39$. Thus it is shown that the oil-field shales were affected by treatment with ocean water very much as the soil sample previously discussed. It is especially interesting to note that the oil-field samples made substantial gains in replaceable magnesium and lost a considerable part of their replaceable sodium by treatment with sea water.

In view of the results of Hissink (3) and Page and Williams (6), on the one hand, and the laboratory experiments reported herein, on the other, it seems safe to say that the ratio of replaceable magnesium to replaceable sodium in a natural deposit, is a more critical indication of previous contact with sea water than is the absolute content of sodium clay.

Although the composition of sea water varies somewhat from place to place, calculations, based on the average analyses as given by Clarke (2), show that the molecular ratios of the dissolved cations of sea water, arranged in ascending order, are as follows: *K*, 1.0; *Ca*, 2.5; *Mg*, 11.5; *Na*, 49.5. This means that sea water contains approximately 4.3 equivalents of sodium to 1 equivalent of magnesium. Neverthless, its action on the experimental samples was found to result in the formation of somewhat more replaceable magnesium than replaceable sodium. The explanation is that magnesium has a much greater power of replacement than sodium.

If it is true, as the results of Taylor and Case strongly indicate, that oil-field clays contain relatively much replaceable sodium, and insignificant amounts of replaceable magnesium, it would seem reasonable to assume that these clays have come into contact with salines quite different in composition from that of ocean water. This, of course, does not necessarily cast doubt on the marine origin of oil deposits. It merely suggests that the oil-field clays have been acted upon by other salines subsequent to the period of marine submergence. There is still other evidence that this may be true. For example, the composition of many oil-field brines has been found to differ greatly from that of ocean water. The ratio of sodium to magnesium, in oil-field brines, appears to be much greater than that in ocean water, Moreover, the ratio of calcium to magnesium is also different. In general it has been found that oil-field brines contain considerably more calcium than magnesium; whereas the ratio of calcium to magnesium in sea water, expressed as chemical equivalents, is approximately 1:4.6.

These differences may be due, in part at least, to the fact that the sodium and magnesium of sea water, upon reacting with the clays of oil fields, have replaced more or less calcium. Consequently the solutions have gained calcium and lost magnesium. However, the practical absence of replaceable magnesium in the oil-field clays indicates that some other factor has been involved.

It is possible that the oil-field clays have undergone alteration through metamorphism or crystallization subsequent to deposition, with the consequent conversion of replaceable magnesium into nonreplaceable forms, either micro-crystalline magnesium clay or some other magnesian mineral. In this connection it should be pointed out that the bentonitic clay, used in our experiments, contains approximately 7 per cent MgO, but that only a small percentage of this is replaceable. The nonreplaceability of this magnesium seems to be due to compact packing of the atoms in the minute montmorillonite crystals, of which this bentonite is composed, rather than to the nature of the chemical bond between magnesium and the alumino-silicate anion. This is indicated by the fact that the replaceability of the magnesium is markedly increased by breaking the small crystals into still smaller units by grinding (4).

Various explanations have been offered by geologists to account for the composition of oil-field brines, but the writers do not care to speculate on this question; neither do they feel competent to discuss the interesting hypothesis of Taylor as to the rôle of sodium clay in oil deposits. It should be pointed out, however, that the absence of magnesium clay in the oil-field shales, and their relatively high content of sodium clay, can hardly be explained by the action of fresh waters subsequent to the period of deposition. If a marine clay should be subjected to the leaching action of waters of meteoric origin, its replaceable sodium would probably be diminished to a much greater extent than its replaceable magnesium, owing to the fact that sodium is more easily replaced than magnesium. Consequently, the sodium clay formed by the action of sea water would tend to be converted more rapidly than magnesium clay into some other form, presumably calcium clay.

As pointed out already, Salgado's results strongly support this view. Case's results on "outcrop samples" of the formation overlying the oil deposits point to the same conclusion. He found that, although the oil-field shales contain relatively much sodium clay, the outcrop samples are composed chiefly of calcium clay. The presumption is that, when first laid down in sea water, both were essentially alike and were similar in composition to the artificially prepared samples

discussed above, but that meteoric waters, having acted on the outcrop samples for a prolonged period, have brought about the replacement of magnesium and sodium by calcium. If this view is sound, it follows, as Case pointed out, either that the materials overlying the oil must have been covered by other sediments without the intervention of a long period of leaching with fresh water, or that sodium salines have later acted on the deposits. If the oil-field shales have been acted upon by salines similar to the brines that are now associated with oil deposits, the effect would probably be for sodium to replace more or less of the magnesium that was acquired during submergence with ocean water and thus to produce clays high in sodium and relatively low in magnesium.

Finally, it seems appropriate to point out that the alkalinity of the oil-field shales and clays, which both Taylor and Case found and to which Taylor attaches special significance, is not necessarily due to sodium clay, nor is it necessarily an indication that these deposits have undergone leaching with fresh water. It is true, sodium clays are more or less alkaline owing to their hydrolytic tendency, and, if leached moderately with water, the soluble product of hydrolysis ($NaOH$) would probably be absorbed to some extent by the colloidal constituents, thus tending to raise the pH of the mass. However, it must be remembered that sea water is itself alkaline (pH 7.5 to 8.2), and any sediment, upon being laid down in sea water, would necessarily be made alkaline irrespective of base exchange. Moreover, calcium carbonate is a common constituent of marine sediments. Thus it follows that the alkalinity of oil-field shales can not be safely attributed solely to their content of sodium clay. It is more probable that sodium clay, alkalinity of sea water, and calcium carbonate have all contributed to the end result, and it is not possible to evaluate the contribution which any one of these factors has made.

REFERENCES

1. L. C. Case, "Base-Replacement Studies of Oklahoma Shales—Critique of Taylor Hypothesis," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 17, No. 1 (January, 1933), pp. 66–79.

2. F. W. Clarke, "Data of Geochemistry," *U. S. Geol. Survey Bull. 330* (1908), p. 23.

3. D. J. Hissink, "The Reclamation of a Part of the Zuyder Zee," *Trans. 6th Commission, Internat. Soc. Soil Sci.*, Vol. A, Part A (1932), p. 183.

4. W. P. Kelley, W. H. Dore, and S. M. Brown, "The Nature of the Base-Exchange Material of Bentonite, Soils and Zeolites, as Revealed by Chemical Investigation and X-Ray Analysis," *Soil Sci.*, Vol. 31 (1930), pp. 25–55.

5. J. Lemberg, "Über Silicatumwandlungen," *Zeit. Deutsch. Geol. Gesell.*, Vol. 28 (1876), pp. 519–62.

6. H. J. Page and W. Williams, "The Effect of Flooding with Sea-Water on the Fertility of the Soil," *Jour. Agr. Sci.*, Vol. 16 (1926), pp. 551–73.

7. C. S. Ross and E. V. Shannon, "The Minerals of Bentonite and Related Clays and their Physical Properties," *Jour. Amer. Ceramic Soc.*, Vol. 9 (1926), pp. 77–96.

8. M. L. M. Salgado, "A Study of some East Anglian Soils Derived from the Jurassic and Cretaceous Sediments, with Special Reference to their Marine Origin," *Jour. Agr. Sci.*, Vol. 23 (1933), pp. 18–30.

9. E. C. Sullivan, "The Interaction between Minerals and Water Solutions with Special Reference to Geologic Phenomena," *U. S. Geol. Survey Bull. 312* (1907). 66 pp.

10. E. McKenzie Taylor, "The Bearing of Base Exchange on the Genesis of Petroleum," *Jour. Inst. Petrol. Tech.*, Vol. 14 (1928), pp. 825–40.

11. ———, "The Replaceable Bases in the Shales and Clays Overlying Petroliferous Strata," *ibid.*, Vol. 15 (1929), pp. 207–10.

12. ———, "An Examination of Clays Associated with Oil-Bearing Strata in the United States," *ibid.*, Vol. 16 (1930), pp. 681–83.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 18, NO. 3 (MARCH, 1934), PP. 368-379

GEOLOGICAL NOTES

SECTION OF PALEOZOIC AND MESOZOIC ROCKS MEASURED AT CINNABAR MOUNTAIN, PARK COUNTY, MONTANA, AND AT MOUNT EVERTS, YELLOWSTONE NATIONAL PARK, WYOMING

	Feet
Quaternary	
Alluvium	
Glacial deposits	
Travertine	
Basalt	
Tertiary	
Volcanic breccias, flows, and agglomerates	
Tertiary (?)	
Eocene (?)	
Reese formation	
Chiefly light colored, but locally greenish, sandstone and conglomerate composed of volcanic ash and rounded grains and pebbles of volcanic material	600*
Cretaceous	
Upper Cretaceous	
Montana group	
Judith River formation (measured 2 miles northwest of Gardiner)	
Top of formation not exposed	
Medium-grained, light gray sandstone; speckled, hard; thin zones weather greenish	45
Concealed	40
Lense of conglomerate filling stream channel. Pebbles and boulders of volcanic material and chert	20
Interbedded black-to-dark and olive-green shale; greenish gray mudstones; and brown, medium-grained sandstones that contain clay blebs	245
Medium-to-coarse-grained, light gray sandstone	42
Alternating black-to-dark and olive-green shale and brown sandstone	66
Brown, medium-grained sandstones containing clay blebs	11
Black and dark green shale	90
Thinly bedded, medium-to-coarse-grained, light buff sandstone	7
Dark green and olive-green shale, black and brown carbonaceous shale and coal, and several layers of thin sandstone that contain plant material. In lower part of this unit is a lense, 300 feet long and 25 feet thick, of conglomerate filling a stream channel. Conglomerate is composed of rounded pebbles and boulders up to 10 inches in diameter and consisting of numerous types of volcanic rocks. Matrix is coarse volcanic sand. Lense weathers dark brown	102
Brown carbonaceous shale	3
Olive-green shale	18
Dark gray quartzite	1
Black-to-dark green and olive shale with bentonite	54
Alternating dark shale and rusty brown sandstone	32

* W. R. Calvert, "The Electric Coal Field, Park County, Montana," *U. S. Geol. Survey Bull. 471* (1912), p. 411.

	Feet
Massively bedded but thinly laminated, cross-bedded, medium-to-coarse-grained sandstone. Light gray when fresh and weathers light and dark buff	49
Conglomerate composed of rounded chert pebbles in matrix of coarse sandstone. Weathers dark brown	7
Brown carbonaceous shale	3
Concealed	28
White bentonite	21
Green bentonite	5
Dark green, brown, and black shale	23
Interbedded dark olive, sandy shale and coarse-grained sandstone	42
Coarse-grained sandstone containing pebbles of chert and quartzite. Weathers dark brown	14
Dark and light olive shale	14
Thinly laminated, cross-bedded, medium-grained light gray sandstone	28
Olive shale, locally sandy	3
Brown carbonaceous shale	2
Dark and light olive shale	29
Thinly laminated, cross-bedded, medium-grained sandstone. Light gray and buff when fresh but weathers dark brown and locally greenish brown	34
Concealed	80
Soft, medium-to-coarse-grained sandstone. Light gray when fresh and weathers buff	22
Sandy shale and green sandstone	11
Sandstone	3
Brown carbonaceous shale	5
Thinly laminated, cross-bedded, medium-grained sandstone. Light gray when fresh but weathers dark greenish brown	4
	1,204 plus

Claggett shale (measured on Mount Everts)	
Parkman sandstone member	
Massively bedded, medium-grained sandstone. Locally cross-bedded. Light gray. Contains a few layers of shale. Where massive, the sandstone weathers into rounded forms	190
Dark gray shale and several sandy layers	70
Sandstone	30
Dark shale. Lower 5 feet is brown carbonaceous shale	50
Massively bedded, medium-grained, cross-bedded, light gray sandstone that weathers into rounded forms	50
	390

Interbedded dark gray shale or mudstone, here and there a greenish layer, calcareous mudstones, dark gray sandstones that weather greenish brown, and light gray sandstones that weather light buff. In this unit of the formation sandstones greatly predominate, being both thinly bedded and in places massive	225
Lithology of shales and sandstones same as above, but increase in the percentage of shales	257
Light gray sandstone, with a few shale zones	36
Shales and sandstones as above. This unit composed of about 25% sandstone and 75% shale	130
	648

	Feet
Eagle sandstone (measured in Electric coal field)	
Sandstone that has variable thickness. Where thin (10 feet) it is fine-grained, hard, gray sandstone that weathers dark brown. Where thick (40 feet) it is medium-grained, gray sandstone that weathers light buff	20
Brown carbonaceous shale, coal, and gray mudstone	35
Sandstone	2
Gray sandy shale	18
Coal	1
Brown carbonaceous shale, coal, and gray mudstone	7
Massively bedded but thinly laminated, irregularly cross-bedded, medium-grained, light gray-to-brown sandstone that weathers buff. Top few feet dark brown	77
Thinly laminated sandstone, bedding varying from "paper sandstone" up to 7 inches. Weathers buff and brown	22
Interbedded gray, locally sandy, shale; brown carbonaceous shale that weathers rusty brown; and coal	30
Thinly laminated, ripple-marked, light gray sandstone that weathers light and dark buff	10
Brown carbonaceous shale with coal streaks	6
Thinly laminated, light gray sandstone that weathers buff	5
Gray shale and brown carbonaceous shale with coal streaks	22
Thinly bedded, cross-bedded, medium-grained grayish brown sandstone and sandy shale	10.5
Dark gray shale and brown carbonaceous shale	30
Brown carbonaceous shale and coal	6.5
Massively bedded; upper 16 feet irregularly cross-bedded; medium-grained; light gray sandstone that weathers light buff. Bipartite sandstone with parting of sandy shale. Upper 5 feet weathers dark brown. (Virgelle sandstone member)	101
	408
Telegraph Creek formation (measured in Electric coal field)	
Thinly bedded, gray sandstone with interbedded blue sandy shale	105
Massive, irregularly bedded, medium-grained, gray sandstone	6
Bluish gray, sandy shale	4.5
Massive, irregularly bedded, medium-grained, gray sandstone	3.5
Blue sandy mudstone interbedded with thinly laminated, minutely cross-bedded, gray sandstone	24
Gray and blue sandy shale with a few thin layers of thinly laminated, gray sandstone	151
Thinly bedded (varying from 0.5 to 6 inches), gray sandstone that weathers buff. Contains a few layers of gray-to-blue sandy shale	24
	318
Colorado group	
Niobrara and Carlile shales (measured on Cinnabar Mountain)	
Black shale, locally sandy, that contains numerous layers of sideritic concretions	1,275
Frontier formation (measured on Cinnabar Mountain)	
Cross-bedded, medium-grained, light gray, speckled sandstone that weathers brown	55
Thinly bedded, black, sandy shale	18
Massive, black, fine-grained sandstone	12
Black, thinly bedded sandstone	7
Black, sandy shale. Bentonite	70
Medium-grained, light gray quartzite including black streaks	5
Black, sandy shale	4
Medium-grained, light gray quartzite containing black streaks	12
Black sandy shale. Bentonite. Fish scales	110

	Feet
Bentonite	1
Black, fine-grained sandstone	6
Coarsely crystalline limestone	.5
	300.5
Mowry shale (measured on Cinnabar Mountain)	
Interbedded light gray, dark gray, and black sandy shale and thinly bedded fine-grained sandstone. Very hard. Some shale weathers light gray. Fish scales	84
Medium-grained, gray quartzite. Bedding averages about 8 inches. Speckled with black specks	6
Dark gray and black, fine-grained sandy shale. Fish scales	120
	210
Thermopolis shale (measured on Cinnabar Mountain)	
Black-to-dark gray, sandy shale. Sandy portions weather dark brown. Plant material present. Hard	310
Light-to-dark gray sandstone: lower part thinly bedded and extensively cross-bedded; upper part very massive and irregular, having no apparent bedding	26
Gray, sandy shale and thinly laminated sandstone	15
Dark gray, sandy shale	45
Light-to-dark gray sandstone, lower part thinly bedded and extensively cross-bedded and upper part massive and irregular, having no apparent bedding	17
Gray, sandy shale and thinly laminated sandstone	20
Black and dark gray, sandy shale; locally fissile; where very sandy it weathers dark brown. Plant material abundant. Iron concretions present	252
	685
Lower Cretaceous	
Cloverly formation (measured on Cinnabar Mountain)	
Greybull sandstone member	
Massive, cross-bedded, medium-grained, light-to-dark gray sandstone, speckled with brown, black, et cetera, colored grains	88
Green mudstone	13
Dark gray, fine-grained limestone that weathers light tan	37
Concealed, probably shale	65
Medium-to-coarse-grained, light brown sandstone, lower part of which contains rounded pebbles of underlying limestone	19
Dark gray shale	8
Fine-grained, gray limestone that weathers dark brown	20
Concealed, probably shale	51
Sill (2.5 feet)	
Maroon, green, gray, and red shale with nodules of fine-grained, red and gray limestone that weather buff	32
Fine-grained, gray sandstone	3
Maroon, green, and gray shale with rounded calcareous nodules	4
Fine-grained, olive-green-to-greenish brown, irregularly bedded limestone	3
Olive gray, sandy shale	5
Pryor conglomerate member	
Massive conglomerate, cross-bedded. Matrix of gray sandstone and rounded pebbles of black chert	24
Concealed, probably sandy shale or thinly bedded sandstone	67
Medium-grained, massive sandstone	13
	452

	Feet
Jurassic (?)	
Upper Jurassic (?)	
Morrison (?) formation (measured on Cinnabar Mountain)	
Green, gray, and dark brown shale	16
Arenaceous limestone	2
Light gray sandstone interbedded with gray shale	55
Fine-to-medium-grained, light gray-to-white sandstone: lower part thinly laminated and upper part minutely cross-bedded	17
Red, maroon, and grayish green shale with a few gray and red sandstones. Bottom contains sulphide nodules	66
Sill (4 feet)	
Grayish green shale	8
Maroon and red shale interbedded with thin red and gray, cross-bedded sandstones	50
Minutely cross-bedded, fine-grained, gray sandstone	1
Red shale	3
Gray shale	5
Minutely cross-bedded sandstone	5
	228
Upper Jurassic	
Ellis formation (measured on Cinnabar Mountain)	
Interbedded coarse-to-medium-grained, arenaceous limestone that contains numerous marine fossils and thinly bedded, irregular, medium-grained, gray sandstone	49
Olive, green, and gray shale with a few sandy layers	150
Sill (27 feet)	
Light gray, dark gray, and black shale, locally calcareous. Marine fossils. Top 5 feet badly crushed and contains specks of sulphides	115
Sill (7 feet)	
Concealed, but probably gray shale	95
Massive, cross-bedded, fine-to-medium-grained sandstone. Ripple marks abundant near top. Lower part dark gray-to-black because of concentration of black grains. Upper part light-to-dark gray, speckled	75
	484
Triassic	
Chugwater formation (measured in Devil's Slide, Cinnabar Mountain)	
Yellowish brown sandstone and gray-to-brown shale with gypsum	25
Gray and brown sandy shale with gypsum beds as thick as 3 inches	18
Red, sandy shale and thin sandstones	59
Gray, sandy shale with beds of gypsum as thick as 1 foot	30
Medium-grained, yellow sandstone	5
	137
Permian	
Phosphoria formation (measured on Cinnabar Mountain)	
Brown and black, phosphatic sandstone	2
Thinly bedded (0.25–4 inches), light gray limestone	40
Black phosphatic sandstone	2
Drab shale	3
Dark gray, finely siliceous limestone that weathers light brown	16
Siliceous, gray limestone that weathers dark brown	21
Gray limestone with thin bands of phosphate. Weathers brown. Bedding varies from 4 inches to 1 foot	22
Light gray limestone, slightly siliceous	7

	Feet
Thinly bedded, dark gray-to-black limestone. Contains small gastropods	6
Unit composed chiefly of rounded tubes, 0.5–4 inches in diameter, of black quartzite, which are arranged normal to bedding. Matrix between tubes is black, phosphatic sand	35
Continuation of above unit excepting fewer tubes	2
Black phosphate	10.5
Basal conglomerate with rounded pebbles of black chert	1
	167.5
Pennsylvanian	
Tensleep sandstone (measured on Cinnabar Mountain)	
Massive; cross-bedded; medium-grained, but locally fine-grained; white-to-buff sandstone that may be locally yellow, red, or brown	130
Pennsylvanian and Mississippian	
Amsden formation (measured on Cinnabar Mountain)	
Massive, very fine-grained, light gray quartzite	4
Fine-grained, white-to-gray limestone	3
Green and yellow shale	0.25
Fine-grained, white-to-gray limestone. Beds vary from 8 inches to 4 feet in thickness	30
Yellow, greenish gray, and red shale	14
Concealed. Non-resistant	60
Dark red, medium-grained sandstone with thin zones of purple shale	3
Massive, white-to-buff, medium-grained sandstone	19
Dark purple and red, sandy shale; fine-grained, bright red sandstone; and fine-grained limestone	6
Basal unit of Amsden is irregular, medium-grained, light buff sandstone locally pink and light red. Lower part of this sandstone contains broken fragments of underlying Madison. It represents deposition upon very rough, erosional surface cut into top of Madison	22
	161.25
Mississippian	
Lower Mississippian	
Madison limestone (measured on Cinnabar Mountain)	
Massively bedded, light gray and in places dark gray limestone that weathers light gray and dove. Upper part arenaceous. Top of formation actually porous sandstone, result of leaching out of calcareous cement during erosional interval preceding deposition of Amsden. Chert lenses common, being dark gray and black	
Lower part of formation more thinly bedded	1,100
Devonian	
Upper Devonian	
Three Forks shale (measured on Cinnabar Mountain)	
Gray, earthy, sandy shale; and gray arenaceous limestone	19
Gray, arenaceous limestone that weathers yellowish brown	9
Alternating gray, arenaceous limestone that weathers yellowish brown and gray shale that weathers yellowish brown	7
Massive, black limestone	11
Gray, argillaceous limestone that weathers yellowish red and brown interbedded with gray, earthy, sandy shale	26
Brown, sandy shale with several thin calcareous zones	11
Black limestone	5.5
Brown, sandy shale	6
Black limestone that grades into shale above and below	3
Light brown, sandy shale	3.5

	Feet
Uniformly and thinly (average 4 inches) bedded black limestone cut by many calcite veins	18
Earthy, brown, sandy shale	4
	122
Middle Devonian	
Jefferson limestone (measured on Cinnabar Mountain)	
Uniformly bedded, black limestone, cut by calcite veins. Bedding more massive than in lower unit	82
Uniformly bedded, thinly bedded (3 inches–2 feet), dark gray-to-black limestone that weathers dark chocolate brown	34
	116
Ordovician (?)	
Upper Ordovician (?)	
Bighorn dolomite (?) (measured on Cinnabar Mountain)	
Massive, light-to-dark gray limestone that weathers into rough pitted surfaces. White and gray chert stringers	91
Thinly bedded (0.5 inch–2 feet, but averaging 2 inches), mottled light and dark gray limestone. White and light gray chert stringers	35
Base not exposed	
	126 plus
Cambrian	
Not exposed in its belt of outcrop on Cinnabar Mountain. Presence of Cambrian was recognized by its position between Bighorn dolomite (?) and pre-Cambrian granite, and also by finding of many fragments of Flathead quartzite	
Pre-Cambrian	
Granite, granitic gneiss, and mica schist. In vicinity of Gardiner thrust fault dacite and andesite porphyries common	

CHARLES W. WILSON, JR.

VANDERBILT UNIVERSITY
NASHVILLE, TENNESSEE
December, 1933

DIFFICULTY OF USING CARTOGRAPHIC TERMINOLOGY IN HISTORICAL GEOLOGY

A number of the anomalies to be found in the Oligocene "series" in California have recently been summarized by R. D. Reed.[1] Anomalous situations, similarly due in large part to the vagueness of the stratigraphic "boundaries" involved in the particular problem, are numerous and of long standing; it is only necessary to cite a few, such as the disputed Danian age of the Midway group of the Gulf Coast, the question of the age of the Lance and Fort Union formations of the interior, and the epoch and series to which the Pontian stage of Europe should be referred. It might be mentioned here that a number of the difficulties which beset anyone who attempts to discuss such a

[1] R. D. Reed, *Geology of California* (Amer. Assoc. Petrol. Geol., 1933), Chapter 8, particularly pp. 160–62.

unit as the Oligocene[2] are perhaps due to the incomparable nature of the entities the comparison of which, through following precedent, is usually thus attempted. For instance, the Oligocene is usually discussed in comparison with the Eocene, Miocene, and Pliocene, all being treated as epochs. This is analogous to a discussion of the Triassic and the Hercynian in similar terms. The process is seemingly a natural outgrowth of the temporary necessity for discussing historical geology in terms of the units most naturally suited to cartographic geology. Unfortunately these units prove to be, as often as not, entirely unsuitable for usage in attempting to trace chronological sequences of geological events throughout any considerable area.

Studies carried on to date in the foraminifer faunas of California yield evidence pointing strongly toward a natural three- or seven-fold classification of the Cenozoic, rather than a two-, five-, or six-fold one, each of which is in use by various workers at the present time; that is, three epochs of major marine transgression over the epicontinental areas have apparently occurred in the California province since the last similar epoch of the Mesozoic. These three epochs of marine transgression presumably represent the three original Cenozoic epochs of Lyell, the Eocene, Miocene, and Pliocene, or at least have been generally considered as such. These three entities, although not of identical nature or magnitude, are in the main similar, and are comparable. In an analogous manner, so are the four geologic time intervals of major regression which separated these epochs of transgression,—namely, the Paleocene, the Oligocene, the Miocene-Pliocene transition (as represented in California by the Pancho Rico beds, for instance), and the Pleistocene,—comparable with each other.[2a] Yet, although a seven-fold time classification may be preferable to a three-fold one from the standpoint of the greater degree of refinement and accuracy thus to be obtained, the attempts to use such a more refined classification, based as it is upon a double rather than a single standard of geologic criteria, seems to have led to considerable confusion, at least when the double standard upon which such a classification is based has not constantly been borne in mind.

The actual distinction between the two types of geologic standards is, of course, not as clear-cut as it might appear to be on paper. It is

[2] See also Jas. B. Dorr, in *Jour. Paleon.*, Vol. 7, No. 4 (1933), pp. 432–38. Dorr believes that certain foraminifer faunas from Mexico (those from the Alazan shale) and northern South America, classified as Miocene by Cushman, are of Lower Oligocene age, because they are to be correlated with the Vicksburg group of southern United States. These same faunas from Latin America may be correlated with those of the Vaqueros and Temblor formations of California, considered to be of Lower Miocene age. The dispute appears to be nomenclatural, not stratigraphic.

[2a] See Note at end of this article.

complicated by the often observed fact that in certain areas, generally though not in all cases those of relatively continuous deposition throughout the Cenozoic, there is evidence of a transgression apparently not referable to one of the three major transgressions previously mentioned, and one which in fact occurred at approximately the time of what is in general a widespread regression of the seas. Yet the time interval represented by such a lesser oscillation of the strand line is hardly to be compared with an epoch, any more than are the lesser but still well defined regressions which occur within the epochs of major transgression to be compared with the greater regressions which apparently took place between the epochs proper. Such smaller periods of transgression, and the rocks which they represent, are more readily comparable, respectively, to the "ages" and "stages" first defined and used by Munier-Chalmas and de Lapparent[3] which in turn may be subdivided into smaller stratigraphic units, the "zones" of Oppel,[4] and, in local basins, into still smaller units to which Fenton's[5] term of "zonule" may be applied.

The Oligocene, as represented in the California province by the Bassendorf and Lincoln formations and their correlatives,[6] appears to represent a stage, and its time equivalent an age, rather than an epoch. Other units in California often referred to the Oligocene, the inclusion of which would increase its magnitude to that of a subepoch, perhaps, are as readily, if not more readily, referable to either upper Eocene or lower Miocene horizons. Whereas one stage is thus represented by the Oligocene, there are six such stages in the stratigraphic sequence referred to the Miocene series in California, which have been described as the Zemorrian, Saucesian, Relizian, Luisian, Mohnian, and Delmontian, from bottom to top, respectively.

[3] *Bull. Soc. Geol. France*, 3 ser., t. 21 (1893), p. 439.

[4] See C. Diener, *Grundzuge zur Biostratigraphie* (1925), pp. 215–41, for a review and discussion of the usage and significance of the term "zone" in stratigraphy.

[5] C. L. Fenton and A. F. Fenton, "Ecologic Interpretation of Some Biostratigraphic Terms," *Amer. Midland Naturalist*, Vol. 11, No. 1 (January, 1928), pp. 20–22.

[6] For foraminiferal faunas of "Lincoln age," see:

Don L. Frizzell and Richard Blackwelder, "Preliminary Analysis of the Type Lincoln Fauna (Oligocene) of Washington," *Micropal. Bull.*, Vol. 4, No. 2 (1933), pp. 53–63.

Wm. W. Valentine, "Notes on Foraminifera from the Type Locality of the San Lorenzo Formation," *ibid.*, Vol. 1, No. 8 (1928), pp. 1–2.

For foraminiferal faunas of "Bassendorf age" see:

J. A. Cushman and Hubert G. Schenck, "Two Foraminiferal Faunules from the Oregon Tertiary," *Univ. California Pub., Bull. Dept. Geol. Sci.*, Vol. 17, No. 9 (1928), pp. 305–24.

D. Dale Condit, "Age of the Kreyenhagen Shale in the Cantua Creek-Panoche Creek District, California," *Jour. Paleon.*, Vol. 4, No. 3 (1930), pp. 259, 262.

These stages have been described and named in a paper,[7] now in press, a summary of the designations being roughly as follows. The type locality for the Zemorrian stage is Zemorra Creek, a branch of Chico Martinez Creek, Kern County. The stage includes rocks carrying the faunal equivalents of Hobson's "transitional San Lorenzo-Vaqueros fauna" of the Santa Cruz Mountains,[8] Barbat and von Estorff's "Vaqueros fauna,"[9] Cushman and Laiming's "Lower member,"[10] and the "Vaqueros" or "*Turritella inezana*" horizons of Loel and Corey.[11] Los Sauces Creek, Ventura County, is the type locality for the Saucesian stage; included in this stage are the correlatives of the "Middle" and "Upper members" of Cushman and Laiming, the "*Buliminella* zone" of Snedden,[12] and the "Barker's Ranch," or "Temblor *B.* zone" horizon of F. M. Anderson.[13] The type locality of the Relizian stage is Reliz Canyon, Monterey County; it embraces correlatives of Barbat's Gould shale[14] and Bagg's "Henry Ranch" fauna,[15] and certain slightly older horizons referred to generally as the "*Siphogenerina hughesi* zone,"[16] and the "button bed,"[17] that is, the interval between the base of the "*Siphogenerina hughesi* zone" and the top of the "*Globigerina transition*."[18] The Luisian stage comprises the equivalents of the so-called "*Valvulineria californica* zone," restricted sense;[19] the type locality is taken on the Highland homocline about 4.5 miles west of Indian Creek, San Luis Obispo County. The Mohnian stage includes equivalents of Rankin's "Lower Modelo" of the Santa Monica Mountains,[20] Galliher's "Lower *Nonion*" zone of Monterey County,[21] somewhat older horizons generally referred to as

[7] "Miocene Foraminifera from Reliz Canyon, Monterey County, California," *Geol. Soc. America* (in press).

[8] *Micropal. Bull.*, Vol. 3, No. 2 (1932), pp. 30–40.

[9] *Jour. Paleon.*, Vol. 7, No. 2 (1933), pp. 164–74.

[10] *Jour. Paleon.*, Vol. 5 (1931), pp. 79–120.

[11] *Univ. California Pub., Bull. Dept. Geol. Sci.*, Vol. 22, No. 3 (1932), pp. 31–410.

[12] *Micropal. Bull.*, Vol. 3, No. 2 (1932), pp. 41–46.

[13] *Proc. California Acad. Sci.*, 4th ser., Vol. 3 (1911), pp. 73–148.

[14] *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 16 (1932), pp. 611–12.

[15] *U. S. Geol. Survey Bull. 268* (1905), pp. 1–77.

[16] Snedden, *op. cit.*
R. M. Kleinpell, *Micropal. Bull.*, Vol. 2 (1930), p. 28.

[17] *U. S. Geol. Survey Bull. 406* (1910).

[18] Kleinpell, *op. cit.*

[19] See R. D. Reed, *op. cit.*, pp. 163, 174, 189, 210, 215, and 217.

[20] *U. S. Geol. Survey Prof. Paper 165-C* (1931), pp. 113–14.

[21] *Micropal. Bull.*, Vol. 2, No. 4 (1931), pp. 71–74.

the "*Baggina californica* zone," and the "*Bulimina uvigerinaformis* zone," which are well developed on the coastal bluffs 15 miles west of Santa Barbara, and the Tice, Rodeo, and Hercules shales and the Briones formation of Contra Costa County.[22] The type locality of the Delmontian stage is taken at the head of Canyon Segundo, south of Del Monte, Monterey County; the stage includes correlatives of Galliher's "Middle *Nonion*" and "Upper *Nonion*" zones, Rankin's "Upper Modelo," the Cierbo and Neroly (or San Pablo group, restricted) formations,[23] and the Pancho Rico formation[24] underlying the correlative of the Jacalitos formation.[25]

It is believed that biostratigraphic classification such as the foregoing will bring out more clearly the natural chronological relationships of the various stratigraphic units of the Cenozoic in California than does a classification in which only the formational names now in use are employed, indispensable as the latter more essentially petrostratigraphic units may be in cartographic work.[26] The faunal changes to be observed in the geologic column, typically in sections where a considerable and continuous sequence of fossiliferous marine strata are to be found,[27] taken together with the structural phenomena, lithologic characters, and the relative geographic distribution of the rocks with which these factors are associated, appear to offer a sounder basis for the natural criteria, or standards, upon which the geologic time scale is built, than does simply the sequence of the essentially petrostratigraphic groups, formations, and members used in cartographic geology, even though a sequence of the latter may locally be entirely marine, unbroken, and partly fossiliferous.

The matter of whether a three-fold classification with a single standard is to be preferred to a seven-fold classification with a double standard in this particular case, is beyond the scope of the present note. Perhaps from the standpoint of a paleobotanist or a mammalian paleontologist, the latter would prove the most convenient. However,

[22] *U. S. Geol. Survey Atlas*, "San Francisco Folio."

[23] See B. L. Clark, "Stratigraphy and Faunal Horizons of the Coast Ranges of California," privately printed, Berkeley, 1929.

[24] R. D. Reed, *Jour. Geol.*, Vol. 33 (1925).

[25] *U. S. Geol. Survey Bull. 691* (1918).

[26] See "Classification and Nomenclature of Rock Units," *Bull. Geol. Soc. America*, Vol. 44 (1933), pp. 423–59.

[27] See A. W. Grabau, *Principles of Stratigraphy*, pp. 1100–02. The classification summarized above has been based primarily upon a composite of twelve chosen sections, each such as recommended by Grabau for a stratigraphic framework, or type, each continuously fossiliferous, and each more or less overlapping another in age, the oldest carrying Upper Eocene fossils at the base and the youngest a Lower Pliocene fauna at the top.

with a natural stratigraphic classification in mind, together with either of the above types of time classifications, both of which may be considered natural,—and the accompanying avoidance of the use of the terms "epoch" and "series" for such different types of units as are represented by the Paleocene and Oligocene on the one hand, as opposed to the Miocene on the other,—it is believed that a number of the stratigraphic "boundary" problems which so complicate and confuse the geologic history of the province will automatically tend to be clarified, and the paleogeographic and historic features dependant upon the involved horizons as datum planes may be brought into sharper relief.

R. M. Kleinpell

Stanford University, California
January 15, 1934

Note received too late to print as footnote 2a (p. 375).

Present knowledge concerning the details of orogeny associated with periods of emergence necessitates that this grouping of major regressions be, of course, very generalized. It should be noted in passing that the Pleistocene, as here referred to, is probably of much greater magnitude than the other units mentioned as similar, and is perhaps to be compared with such "revolutions" as the Killarney and Hercynian, or the Caledonian and Nevadian. The Paleocene may be of lesser magnitude, like such "disturbances" as the Palisades, Acadian, and Green Mountains The two other major periods of regression mentioned are probably even smaller.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 18, NO. 3 (MARCH, 1934), PP. 380-383

REVIEWS AND NEW PUBLICATIONS

Report on Aerial Survey Operations in Australia During 1932. By W. G. Woolnough. Commonwealth of Australia (Canberra, 1933). 78 pp., 3 pls., 1 map.

When Doctor Woolnough, geological adviser to the Commonwealth Government, was in the United States in 1930 on an inspection tour of oil fields, he was greatly impressed with the use of airplane observations and photographs in geological surveying. On his return to Australia he arranged and carried out, with the collaboration of the Royal Australian Air Force, an extensive program of flights, some of the results of which are described in the report under review. Photographic surveys were carried out in most of the areas that are considered favorable for oil prospecting. The flights constitute a virtual circumnavigation of the continent, and as Doctor Woolnough accompanied these expeditions, he had an unusual opportunity to become familiar with the often subtle details of aerial observations and interpretations of photographs. Geologists who make occasional flights may be interested to know that he "scarcely began to appreciate the significance of such details until he had completed at least 100 hours of flying." Particular attention was devoted to areas where detailed ground geological surveying had been completed or was being carried on, and to areas where test wells had been bored, as the result of skilled geological advice or from the use of divining rods. In some of these areas it was amply demonstrated, as was to be expected from experience elsewhere, that observations and photographs from the air reveal significant geological features that escape, or even defy, ground observations. For example, in the Fitzroy River area—in the Permo-Carboniferous rocks of the Kimberly division of western Australia—the aerial methods confirm the ground mapping in the hilly country, but in the lowlands they plainly show folds that were not suspected during the ground surveying.

The report includes computations for determining the orientation of photographs independently of compass bearings and for determining the height of objects from the length of shadows as measured on photographs, and also a discussion of the origin of the bitumen found at many places on the south coast of Australia, regardless of the character or age of the rocks. It is attributed to transportation by the Antarctic Current from some distant source, probably Antarctic.

It is repeatedly emphasized that aerial surveys can not take the place of ground mapping, but that a combination of the two will lead to effective and rapid work. The results of the surveys made by Doctor Woolnough doubtless will be used immediately in oil prospecting, and they also constitute an addition to knowledge of the geology of Australia.

W. P. Woodring

United States Geological Survey
Washington, D. C.
January 26, 1934

Gisement pétrolifères de Iraq (The Petroliferous Beds of Iraq). By C.-P. NICOLESCO. Les Presses Modernes, 45, Rue de Maubeuge, Paris (1933). 221 pp., 18 figs. 6.5×10 inches.

In his book Nicolesco considers all the problems related to the question of petroliferous beds in Iraq, but, as stated by the author himself, it is chiefly a geological study. Thus, out of the 206 pages which comprise the text of this work, 141 are devoted to geologic problems. The book is completed by a bibliography of 150 titles, many of which are only distantly connected with the subject.

As the author points out, he knows nothing of the recent prospection work carried out by the I.P.C. This voluminous book is based, therefore, on uncertain information, of which some is very old and some even inaccurate.

Chapter I is devoted to a short historical study and to an enumeration of the principal seepages of petroleum and asphalt in Iraq, grouped by anticlinal areas. A tectonic map of Iraq, scale roughly 1:5,000,000, notes the approximate distribution of the principal folds of the plain of Iraq.

Chapter II is entitled "Geography and Geomorphology" and gives some information on the population and orography of the region.

Chapter III, under the title of "Geology," is the one which most interests us here. A few historical pages are followed by 2 tables, showing the outstanding stratigraphic features. The stratigraphic description which follows is drawn, for the most part, from the work of H. de Böckh, G. M. Lees, F. G. S. Richardson[1] and from the older book of F. H. Pascoe.[2] Some of these data are so distorted that errors have arisen.

In the paleontological section of the book the author quotes the chief species discovered, following the same stratigraphic divisions as before. Unfortunately, the places in which these fossils were found are not noted, and the bibliographic references which relate to them are not given.

Finally, the stratigraphic section discusses the classification of the formations made by various authors. A stratigraphic table of the Neogene shows the correlation between the divisions proposed by the various authors from Loftus (1855) to de Böckh (1929).

In the tectonic section the author gives, in accordance with Pascoe's description, a geologic sketch of the region studied by Pascoe and reproduces profiles which give a very incomplete idea of the tectonic structure. Moreover the conclusions which he draws from these data are, at the least, unexpected:[3]

> both these two structural types—anticlines and domes—observed in Iraq possess characteristics belonging to diapir folds.

This conception is all the more strange as analogous structures in Persia have been described in the publications of H. G. Busk[4] and F. G. S. Richardson[5]

[1] H. de Böckh, G. M. Lees, F. G. S. Richardson, "Contribution to the Stratigraphy and Tectonics of the Iranian Ranges," in J. W. Gregory, *Structure of Asia* (London, 1929).

[2] E. H. Pascoe, "Geological Notes on Mesopotamia with Special Reference to Occurrences of Petroleum," *Mem. Geol. Survey India*, Vol. 48 (1922).

[3] P. 81.

[4] H. G. Busk, *Earth Flexures* (Cambridge, 1929).

[5] F. G. S. Richardson, "The Geology and Oil Measures of South-West Persia," *Jour. Inst. Petrol. Tech.*, Vol. 10 (1924).

and as G. M. Lees[6] has recently given an excellent summary of the peculiar tectonic structure of the Lower Fars in Persia. In particular, he has shown that:[7]

> The Lower Fars lies between the Rijid Asmari limestone below, and the comparatively competent Middle and Upper Fars and Bakhtiari formations above. The saline beds behave like a lubricant and are responsible for the sliding of these higher rocks over the lower, causing an extreme structural discordance between the higher formations and the under-lying Asmari limestone.

The term "diapir" has, moreover, already been applied so often to tectonic structures, which have no connection, that its meaning is to-day very obscure.

A paleontological sketch shows the extension of the principal beds.

A geologic map, scale roughly 1:5,000,000, illustrates the chapter. The boundaries on it are drawn, with very few exceptions, from the geologic map of the world by Fr. Beyschlag,[8] scale 1:15,000,000. Many of the details given on it are incorrect.

Chapter IV is devoted to the petroliferous formations. The author notes the reservoir character of the "main limestone" (Eocene, Oligocene, Asmari), and then describes some outcrops of gypsum, salt, salt water, sulphur, and petroleum.

The problem of the "mother-rocks" is discussed in Chapter V. The author admits that these are Eocene, Oligocene, Asmari, and Lower Fars rocks with salt facies.

A paragraph on prospecting gives an account of the research work done and discusses analogies with other beds.

Finally, Chapter VI (pp. 142–206) discusses questions of economic character: permits, concessions, interested companies, production, transport, et cetera.

Mr. Nicolesco's book shows us how difficult it is to present a geologic synthesis of a country concerning which so little has been published: a few pages of critical summary of the data contained in the bibliography would certainly have been of great service, whereas the same data distorted and spun out in 140 pages of inaccurate French are of much less use.

H. DE CIZANCOURT

PARIS, FRANCE

RECENT PUBLICATIONS

CANADA

"Oil and Gas in Western Canada," by G. S. Hume. *Canada Geol. Survey Econ. Geol. Ser. 5* (Ottawa, 1933). 2d. ed. 359 pp., 26 figs. Size, 6.5×9.75 inches. Paper. Price, $0.75.

GENERAL

Die Orogentheorie (Orogenic Theory), by L. Kober. Gebrüder Borntraeger, Berlin (1933). 184 pp., 50 figs. Size, 6×9 inches. Price: paper, 14.80 RM.; cloth, 16 RM.

[6] G. M. Lees, "Salt—Some Depositional and Deformational Problems," in "Symposium on Salt Domes," *Jour. Inst. Petrol. Tech.*, Vol. 17 (1931).

[7] P. 263.

[8] Fr. Beyschlag, *Geologische Karte der Erde* (Berlin, 1929–1932).

The Deformation of the Earth's Crust, by Walter H. Bucher. Princeton University Press (New Jersey, 1933). 531 pp., 100 figs. Size, 23 cm. Cloth. Price, $5.00.

"Catalogue of Small-Scale Geologic Maps," by W. H. Bucher *et al. Natl. Research Council Div. Geol. & Geogr. Rept. of Com. on Tectonics* (Washington, D. C., April 22, 1933). 138 mimeog. pp. Useful for broader regional studies, with chief emphasis on modern maps. North America, Alaska, Canada, United States, Mexico, Central America, West Indies. Prepared under auspices of committee on tectonics, G. R. Mansfield, chairman. Price, $1.00.

"Representation of Structural Data on Geologic Maps," by D. F. Hewett, George W. Stose, and G. R. Mansfield. *Natl. Res. Coun. Div. Geol. Geogr. Rept. Com. Tectonics Exhibit B* (Washington, D. C., April 22, 1933). 5 mimeog. pp. and 4 notebook sheets of symbols. The symbols have been approved by the director of the U. S. Geological Survey. They are of particular interest to those who have to do with the construction of geologic maps. For the report, apply to: National Research Council, 2101 Constitution Avenue, Washington, D. C. Free. For the symbols, apply to: Director, U. S. G. S., Washington, D. C. Free.

"Sedimentation und Erdölmuttergesteine" (Sedimentation and Petroleum Mother Rocks), by Fritz-Erdmann Klingner. *Petrol. Zeits.* (Berlin), Vol. 30, No. 1 (January 3, 1934), pp. 9–14; 3 figs.

GEOPHYSICS

"A Contribution to the Theory of the Interpretation of Resistivity Measurements Obtained from Surface Potential Observations," by R. J. Watson. *Amer. Inst. Min. Met. Eng. Tech. Pub. 518* (1934). 34 pp., 26 figs. 29 West 39th Street, New York.

"A Magnetic Gradiometer," by Irwin Roman and Thomas C. Sermon. *Amer. Inst. Min. Met. Eng. Tech. Pub. 542* (1934). 17 pp., 6 figs.

GERMANY

"Das Erdöl in Deutschland und die Frage seiner Aufsuchung" (Petroleum in Germany and the Search for It), by A. Bentz. *Petrol. Zeits.* (Berlin), Vol. 29, No. 50 (December 20, 1933), pp. 4–8; 1 fig.

JAPAN

"The Upper Cretaceous Oil-Bearing Sedimentary Rocks of Hokkaido, Japan," by Kunio Uwatoko and Ken-itiro Ohtatsume. *Hokkaido Imp. Univ. Jour. Faculty Science*, Ser. 4, Vol. 2, No. 2 (1933), pp. 133–61; 9 figs.

MEXICO

"The Permian of Southwestern Coahuila, Mexico," by Robert E. King. *Amer. Jour. Sci.* (New Haven, Conn.), Vol. 27, No. 158 (February, 1934), pp. 98–112; 4 figs.

TURKEY

"Das Erdölvorkommen bei Pulk (Türkei)" (Petroleum Indications near Pulk, Turkey), by Gr. Petunnikov. *Petrol. Zeits.* (Berlin), Vol. 29, No. 50 (December 20, 1933), pp. 12–15; 8 figs.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 18, NO. 3 (MARCH, 1934), PP. 384-427

THE ASSOCIATION ROUND TABLE

MEMBERSHIP APPLICATIONS APPROVED FOR PUBLICATION

The executive committee has approved for publication the following candidates for membership in the Association. This does not constitute an election, but places the names before the membership at large. If any member has information bearing on the qualifications of these nominees, he should send it promptly to J. P. D. Hull, business manager, Box 1852, Tulsa, Oklahoma. (Names of sponsors are placed beneath the name of each nominee.)

FOR ACTIVE MEMBERSHIP

J. H. Derden, San Antonio, Tex.
Martin Matson, Ed. W. Owen, Herschel H. Cooper

Henryk Bronislaw Stenzel, College Station, Tex.
John T. Lonsdale, Frederick A. Burt, B. Coleman Renick

FOR ASSOCIATE MEMBERSHIP

John Haviland Maxson, Pasadena, Calif.
John P. Buwalda, Ian Campbell, R. D. Reed

Lawrence O'Donnell, New Iberia, La.
R. A. Steinmayer, Albert G. Wolf, R. B. Paxson

Bernard Wasserfallen, Miri, Sarawak
D. Trumpy, C. W. Tiedemann, Richard E. Koch

Henry Rollins Wofford, Jr., San Antonio, Tex.
B. Coleman Renick, John R. Sandidge, John T. Lonsdale

FOR TRANSFER TO ACTIVE MEMBERSHIP

W. Blair McCarter, Houston, Tex.
L. T. Barrow, L. P. Teas, Wallace E. Pratt

FINANCIAL STATEMENT, 1933

To the EXECUTIVE COMMITTEE,
THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS,
TULSA, OKLAHOMA

We have examined the accounting records of THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS for the year ended December 31, 1933, from which the following statements have been prepared:

Exhibit

A Statement of Financial Condition as at December 31, 1933.
B Statement of Income for the year ended December 31, 1933.
C Statement of Income from Publications for the year ended December 31, 1933.
D Statement of General and Administrative Expenses for the year ended December 31, 1933.

Cash in Banks was confirmed by the depositaries; Reserves of $2,536.00 have been provided for Accounts Receivable from Members and Others; Inventories of Printed Matter are at current appraised values and represent the supply of publications to meet anticipated requirements; Investments were verified by inspection or confirmation from the depositaries and are stated at market value.

During the year 1933 the Association reduced the Active Membership annual dues from $15.00 to $12.00 and the Associate Membership annual dues from $10.00 to $8.00. The amount of dues transferred to Income from Bulletins was accordingly reduced from $8.00 to $6.00.

At December 31, 1933, the Association had entered into Contracts for the printing of "Problems of Petroleum Geology" and the estimated cost thereof of approximately $4,500.00 is not reflected in the attached statements.

Subject to the foregoing, in our opinion, the accompanying statement of Financial Condition and related Statements of Income and Expenses respectively correctly reflect the financial condition of THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS at December 31, 1933, and the results of its operations for the year ended on that date.

(Signed) ARTHUR YOUNG & CO.
Accountants and Auditors

TULSA, OKLAHOMA
January 31, 1934

EXHIBIT A

STATEMENT OF FINANCIAL CONDITION AS AT DECEMBER 31, 1933

ASSETS	*Total*	*General Fund*	*Publication Fund*	*Research Fund*
CURRENT ASSETS:				
Cash in Banks:				
First National Bank and Trust Company	$10,803.17	$ 5,581.85	$ 5,221.32	$ —
National Bank of Commerce	305.61	305.61	—	—
TOTAL CASH IN BANKS	$11,108.78	$ 5,887.46	$ 5,221.32	$ —
Accounts Receivable:				
Members (Less Reserve for Doubtful Accounts $2,244.00)	$ 969.00	$ 969.00	$ —	$ —
Advertising (Less Reserve for Doubtful Accounts $292.00)	207.00	207.00	—	—
Printed Matter	295.25	76.05	219.20	—
Miscellaneous	35.20	35.20	—	—
TOTAL ACCOUNTS RECEIVABLE	$ 1,506.45	$ 1,287.25	$ 219.20	$ —
Inventory—At Current Appraised Value	$15,259.70	$13,420.99	$ 1,838.71	$ —
Accrued Interest Receivable (Less Reserve $732.49)	$ 621.84	$ 502.93	$ 95.20	$ 23.71
TOTAL CURRENT ASSETS	$28,496.77	$21,098.63	$ 7,374.43	$ 23.71
INVESTMENTS:				
Bonds and Savings Certificates—At Market Value (Cost $50,639.04)	$37,019.94	$25,868.40	$10,094.81	$1,056.73
Life Membership Investment Fund (Cost $629.44)	604.44	604.44	—	—
TOTAL INVESTMENTS	$37,624.38	$26,472.84	$10,094.81	$1,056.73
FIXED ASSETS:				
Furniture and Fixtures	$ 3,294.29	$ 3,294.29	$ —	$ —
Less: Reserve for Depreciation	1,833.33	1,833.33	—	—
TOTAL FIXED ASSETS	$ 1,460.96	$ 1,460.96	$ —	$ —
PREPAID AND DEFERRED CHARGES:				
Paper Stock on Hand at Printers	$ 1,682.60	$ 1,682.60	$ —	$ —
Prepaid Insurance	23.39	23.39	—	—
Geology of Natural Gas	349.84	—	349.84	—
Preliminary Costs on Problems of Petroleum Geology	736.38	736.38	—	—
TOTAL PREPAID AND DEFERRED CHARGES	$ 2,702.21	$ 2,442.37	$ 349.84	$ —

LIABILITIES AND SURPLUS	*Total*	*General Fund*	*Publication Fund*	*Research Fund*
CURRENT LIABILITIES:				
Accounts Payable	$ 881.95	$ 881.95	$ —	$ —
Society of Economic Paleontologists and Mineralogists	14.00	14.00	—	—
TOTAL CURRENT LIABILITIES	$ 895.95	$ 895.95	$ —	$ —
DEFERRED INCOME:				
Active Membership Dues—1934	$ 4,942.00	$ 4,942.00	$ —	$ —
Associate Membership Dues—1934	568.00	568.00	—	—
Active Membership Dues—1935	2.80	2.80	—	—
Subscriptions to Bulletin—1934	1,488.00	1,488.00	—	—
Subscriptions to Bound Volume XVII	256.00	256.00	—	—
Subscriptions to Problems of Petroleum Geology	401.50	401.50	—	—
TOTAL DEFERRED INCOME	$ 1,768.30	$ 7,658.30	$ —	$ —
SIDNEY POWERS MEMORIAL	$ 167.50	$ 167.50	$ —	$ —
FUND SURPLUS:				
Balance—December 31, 1932	$58,175.99	$43,192.67	$14,237.16	$ 746.16
Net Profit (−Loss) for the year ended December 31, 1933—Exhibit B	3,476.58	−439.62	3,581.92	334.28
Balance—December 31, 1933	$61,652.57	$42,753.05	$17,819.08	$1,080.44
TOTAL LIABILITIES AND ...				

EXHIBIT B

STATEMENT OF INCOME FOR THE YEAR ENDED DECEMBER 31, 1933

	General Fund	*Publication Fund*	*Research Fund*	*Total*

EXHIBIT B

STATEMENT OF INCOME FOR THE YEAR ENDED DECEMBER 31, 1933

	Members	Annual Dues	General Fund		Publication Fund		Research Fund		Total	
OPERATING INCOME:										
DUES:										
Active Membership	1,427	$12.00		$17,124.00		$ —		$ —		$17,124.00
Associate Membership	35	12.00	$ 420.00		$ —		$ —		$ 420.00	
Associate Membership	260	8.00	2,080.00		—		—		2,080.00	
	295			2,500.00		—		—		2,500.00
	1,722			$19,624.00		$ —		$ —		$19,624.00
Deduct: Transfer to Income from Bulletins										
Active Membership	1,427	$6.00	$8,562.00		$ —		$ —		$ 8,562.00	
Associate Membership	295	6.00	1,770.00		—		—		1,770.00	
	1,722			$10,332.00	—	—	—	—		$10,332.00
				$ 9,292.00		$ —		$ —		$ 9,292.00
PUBLICATIONS—Net Income (−*Loss*) Exhibit C				−6.24		2,033.30		—		2,027.06
CONVENTION RECEIPTS (NET)				9.96		—		—		9.96
TOTAL OPERATING INCOME				$ 9,295.72		$2,033.30		$ —		$11,329.02
GENERAL AND ADMINISTRATIVE EXPENSES—EXHIBIT D				10,795.38		16.90		—		10,812.28
Net Operating Income (−*Loss*)				$−1,499.66		$2,016.40		$ —		$ 516.74
NON-OPERATING INCOME:										
Interest on Investments			$ 1,379.58		$620.08		$ 61.78		$ 2,061.44	
Interest on Checking Account			133.29		14.19		—		147.48	
Miscellaneous			43.27		—		—		43.27	
TOTAL NON-OPERATING INCOME			$1,556.14		$634.27		$ 61.78		$ 2,252.19	
Add: Adjustment of Book Value of Investments to Market			−496.10		931.25		272.50		707.65	
				$ 1,060.04		$ 1,565.52		$334.28		$ 2,959.84
Net Profit (−*Loss*) Transferred to Surplus Exhibit A				$ −439.62		$ 3,581.92		$334.28		$ 3,476.58

EXHIBIT C

STATEMENT OF INCOME FROM PUBLICATIONS FOR THE YEAR ENDED DECEMBER 31, 19

	General Fund—Bulletins		Publication Fund		Total	
OPERATING INCOME:						
Dues Transferred—						
Active Membership	$ 8,562.00			$ —		$ 8,5
Associate Membership	1,770.00			—		1,77
		$10,332.00		$ —		$10,33
Sale of Bulletins—						
Subscriptions	$ 3,339.13			—	$ 3,339.13	
Advertising	2,689.55			—	2,689.55	
		6,028.68				6,02
		$16,360.68				$16,36
Sale of Bound Volumes and Special Publications—						
Bound Volumes	$ 1,711.70		$ —		$ 1,711.70	
Back Numbers	485.02		—		485.02	
Indexes	36.60		—		36.60	
Alberta Symposium	22.80		—		22.80	
Structure I	—		260.26		260.26	
Structure II	315.93		—		315.93	
Continental Drift	—		159.85		159.85	
Geology of California	—		3,555.73		3,555.73	
		$ 2,572.05		$3,975.84		$ 6,54
TOTAL OPERATING INCOME		$18,932.73		$3,975.84		$22,90
OPERATING COSTS:						
Manager's Salary (Proportion)	$ 2,452.00		$ 93.24		$ 2,545.24	
Editorial Secretary's Salary	3,533.60		—		3,533.60	
Cost of Printing Bulletin	7,773.95		—		7,773.95	
Cost of Engraving	1,195.05		—		1,195.05	
Cost of Printing Separates	198.05		—		198.05	
Stencil Corrections and Mailing	133.72		—		133.72	
Binding Volume XVI	406.30		—		406.30	
Geology of California—Printing and Binding	—		2,571.06		2,571.06	
Copyright Fees	24.00		—		24.00	
Discount on Publications	19.64		30.35		49.99	
Postage—Bulletin	533.05		—		533.05	
Purchase of Back Numbers	17.50		—		17.50	
	$16,286.86		$2,694.65		$18,981.51	
INVENTORY:						
December 31, 1932	$16,073.10		$1,086.60		$17,159.70	
December 31, 1933	13,420.99		1,838.71		15,259.70	
Decrease (−*Increase*)	$ 2,652.11		$−752.11		$ 1,900.00	
Total Cost of Publications Sold		$18,938.97		$ 1,942.54		$20,88
Net Income (−*Loss*) from Publications—Transferred to Exhibit B		$ −6.24		$ 2,033.30		$ 2,027

EXHIBIT D

STATEMENT OF GENERAL AND ADMINISTRATIVE EXPENSES FOR THE YEAR ENDED DECEMBER 31, 1933

GENERAL FUND:		
Manager's Salary (Proportion)		$ 1,929.19
Clerical Salaries		4,717.67
Office Rent		300.00
Telephone and Telegraph		255.99
Postage—General		941.37
Printing and Stationery		365.04
Office Supplies and Expenses		220.68
Insurance		117.65
Audit Fee		350.00
Traveling Expenses (National Research Council)		192.53
Freight and Express		5.65
Tax on Checks		7.12
Exchange and Refunds		22.18
Donations to Society of Economic Paleontologists and Mineralogists		348.00
Dallas Meeting		22.15
Miscellaneous		5.23
Bad Debts		665.50
Depreciation of Office Furniture and Fixtures		329.43
TOTAL—GENERAL FUND		$10,795.38
PUBLICATION FUND:		
Bad Debts	$15.05	
Miscellaneous	1.85	
TOTAL—PUBLICATION FUND		$ 16.90
TOTAL—TRANSFERRED TO EXHIBIT B		$10,812.28

THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS MEMBERSHIP LIST

MARCH 1, 1934

HONORARY MEMBERS

The executive committee may from time to time elect as honorary members persons who have contributed distinguished service to the cause of petroleum geology. Honorary members shall not be required to pay dues.—*Sec. 6, Article III, of the Constitution.*

LIFE MEMBERS

The executive committee may grant life membership to members who have paid their dues and are otherwise qualified.—*Sec. 2, Article III, of the Constitution.*

On the payment of three hundred dollars ($300.00) any member in good standing shall be declared a life member and thereafter shall not be required to pay annual dues.—*Sec. 2, Article I, of the By-Laws.*

MEMBERS

Any person engaged in the work of petroleum geology or in research pertaining to petroleum geology or technology is eligible to active membership, provided he is a graduate of an institution of collegiate standing, in which institution he has done his major work in geology, or in sciences fundamental to petroleum geology, and in addition has had the equivalent of three years' experience in petroleum geology or in the application of these other sciences to petroleum geology or to research in petroleum geology or technology; and provided further that in the case of an applicant for membership who has not had the required collegiate or university training, but whose standing in the profession is well recognized, he shall be admitted to membership when his application shall have been favorably and unanimously acted upon by the executive committee; and provided further that these requirements shall not be construed to exclude teachers and research workers in recognized institutions whose work is of such character as in the opinion of the executive committee shall qualify them for membership.

Active members alone shall be known as members.—*Sec. 1, Article III, of the Constitution.*

ASSOCIATES

Any person having completed as much as thirty hours of geology (an hour shall here be interpreted as meaning as much as sixteen recitation or lecture periods of one hour each, or the equivalent in laboratory) in a reputable institution of collegiate or university standing, or who has done field work equivalent to this, is eligible to associate membership, provided at the time of his application for membership he shall be engaged in geological studies in an institution of collegiate or university standing, or shall be engaged in petroleum geology; and any person who is a graduate of an institution of collegiate standing, in which he has done his major work in sciences fundamental to petroleum geology or petroleum technology, and who has had the equivalent of one year's experience in the application of his science to the study of petroleum geology, shall be eligible to associate membership, provided at the time of his application for membership he shall be engaged in investigations in the broader subject of petroleum geology and technology.

Associate members shall be known as associates.

Associates shall enjoy all the privileges of membership in the Association, save that they shall not hold office, sign applications for membership, or vote; neither shall they have the privilege of advertising their affiliation with the Association in professional cards or professional reports or otherwise.—*Sec. 3, Article III, of the Constitution.*

HONORARY MEMBERS
(**Deceased)

Decker, Charles E., 508 Chautauqua Ave., Norman, Okla.
**Dumble, E. T.
Goodrich, Harold B., 1628 S. Cincinnati, Tulsa, Okla.
Hill, Robert T., Hotel Commodore, Los Angeles, Calif.
Orcutt, W. W., Union Oil Company Bldg., Los Angeles, Calif.
**Salisbury, R. D.
Smith, George Otis, 2137 Bancroft Pl., Washington, D.C.
**Udden, Johan August
**von Höfer, Hans Hofrat
White, David, U. S. Geological Survey, Washington, D.C.
**White, I. C.

COMPLETE LIST OF MEMBERS, ASSOCIATES, HONORARY MEMBERS, AND LIFE MEMBERS

Honorary	6
Life	2
Members	1,634
Associates	401
Total	2,043

EXPLANATION OF SYMBOLS

*Honorary member. †Life member. ||Associate. Members are not marked. The year refers to the date of election to the Association, not necessarily to class of membership.

||Abbott, John L., 1007 Fort Worth Natl. Bank Bldg., Fort Worth, Tex. '27
Absher, William F., Geological Dept., Empire Gas & Fuel Co., Bartlesville, Okla. '20
Ackers, A. L., Stanolind Oil & Gas Co., Box 758, Midland, Tex. '25
Adams, Frank C., Gem Oil Co., 1506 Esperson Bldg., Houston, Tex. '27
Adams, John Emery, Drawer R, Midland, Tex. '29
Adams, W. C., Deep Rock Oil Corp., Atlas Life Bldg., Tulsa, Okla. '24
Addison, Carl C., 3032 N. Twenty-First St., Kansas City, Kan. '30
Adler, Joseph L., 126 Garnet St,, Houghton, Mich. '30
Aguerrevere, Pedro I., Sur. 3, No. 94, Caracas, Venezuela, S. A. '24
Aguerrevere, Santiago E., Sur. 3, No. 94, Caracas, Venezuela, S. A. '24
Aid, Herbert, c/o Mrs. J. Lide Weaver, 2001 Hemphill St., Fort Worth, Tex. '28
Aimer, James D., Box 375, Nacogdoches, Tex. '26
Ainsworth, David, 604 N. Fountain Ave., Wichita, Kan. '23
Ainsworth, William L., 301 N. Yale St., Wichita, Kan. '21
Aitken, William E., Huntley & Huntley, Grant Bldg., Pittsburgh, Pa. '32
Albertson, Maurice M., Shell Petr. Corp., Box 2099, Houston, Tex. '20
Albrecht, Helmuth, Burbach-Kaliwerke Aktiengesellschaft, Kaiser-Otto-Ring. '25
Magdeburg, Germany '32
||Alcorn, Avary Hunt, 602 Citizens Natl. Bank Bldg., Tyler, Tex. (Mail returned) '32
Aldrich, G. Frank, 2024 Wilshire Blvd., Fort Worth, Tex. '25
Alexander, A. M., 18 E. One Hundred Ninety-Ninth St., New York, N. Y. '31
Alexander, C. I., Magnolia Petr. Co., Shreveport, La. '27
Allan, John Andrew, University of Alberta, Edmonton, Alta., Canada '30
Allan, Thomas H., Stanolind Oil & Gas Co., 417 First Natl. Bank Bldg., Wichita, Kan. '24
Allen, Devere F., 3000 Somers Court, Topeka, Kan. '29
Allen, E. G., 201 El Morado Court, Ontario, Calif. (Mail returned) '17
Allison, A. P., Sun Oil Co., 820 Esperson Bldg., Houston, Tex. '21

Althaus, H. E., Astra Romana, Campina, Roumania...'28
Ambrose, A. W., Empire Gas & Fuel Co., Bartlesville, Okla...'19
Ames, Edward W., Box 169, San Antonio, Tex...'19
Anderson, Carl C., Box 2025, Amarillo, Tex...'32
Anderson, Frank M., 58 Hillcrest Rd., Berkeley, Calif...'24
Anderson, J. L., Tropical Oil Co., El Centro, Colombia, S. A...'29
||Anderson, Richard S., Drawer 2040, Tulsa, Okla...'31
Anderson, W. D., 1718 Milam Bldg., San Antonio, Tex...'27
Andrau, E. W. K., Shell Petr. Corp., Houston, Tex...'32
Andrews, Philip, Venezuela Gulf Oil Co., Ciudad Bolivar, Venezuela, S. A...'25
||Angle, W. M., 1811 Esperson Bldg., Houston, Tex...'30
Apfel, Earl T., Dept. of Geology, Syracuse University, Syracuse, N. Y...'29
Applin, Paul L., 2200 Edwin Ave., Fort Worth, Tex...'19
Argabrite, William Graeme, Box 33, Lewisburg, W. Va...'28
Arick, Millard B., Box 938, McCamey, Tex...'27
||Armor, Mildred V., 3711 Classen Blvd., Oklahoma City, Okla...'30
Armstrong, Earle N., 3902 Cheyenne Rd., Amarillo, Tex...'33
Armstrong, Harold K., Room 838, 727 W. Seventh St., Los Angeles, Calif...'27
Armstrong, J. M., Sinclair Prairie Oil & Gas Co., Box 1990, Fort Worth, Tex...'18
Arnold, Harry H., Jr., 749 E. Liberty St., Clarion, Pa...'27
||Arnold, Henry C., Barnsdall Oil Co., Box 2039, Tulsa, Okla...'30
Arnold, Ralph, 1201 E. California St., Pasadena, Calif...'18
Aronson, Sam M., Atlantic Oil Prod. Co., 701 Magnolia Bldg., Dallas, Tex...'24
Artman, George W., 2733 N. W. Seventeenth St., Oklahoma City, Okla...'25
Athy, Lawrence F., Geophysical Div., Continental Oil Co., Ponca City, Okla...'26
Atkinson, William H., 26th Floor Ramsey Tower, Oklahoma City, Okla...'22
Atwill, E. R., Box 126, San Gabriel, Calif...'31
Aurand, Harry A., 1350 Bellaire St., Denver, Colo...'26
Aurin, Fritz L., Southland Royalty Co., Ponca City, Okla...'17
Autry, Vernon E., Humble Oil & Refg. Co., Box 299, Wichita Falls, Tex...'26
Avery, C. Dwight, U. S. Geological Survey, 3240 Interior Bldg., Washington, D. C...'28

Bace, A. C., Stanolind Oil & Gas Co., Philcade Bldg., Tulsa, Okla...'24
Bacon, Charles S., Jr., Dept. of Geology, Riverside Junior College, Riverside, Calif...'29
Baden, Martin W., Box 520, Winfield, Kan...'21
Bagg, Rufus M., Box 386, Appleton, Wis...'27
||Bailey, Donald G., 798½ Kensington Rd., Los Angeles, Calif...'31
Bailey, James P., N. V. Ned. Pac. Petr. Mij., 26 Tanah Abang West, Batavia-Centrum, Java, D. E. I...'31
||Bailey, Joe, 1201 E. Eleventh St., Winfield, Kan...'30
Bailey, Thomas L., Box 713, Ventura, Calif...'24
Bain, H. Foster, Copper & Brass Research Assoc., 25 Broadway, New York, N. Y...'26
Baird, Chester A., Venezuela Gulf Oil Co., Apartado 234, Maracaibo, Venezuela, S. A...'21
Baker, Arthur A., U. S. Geological Survey, Washington, D. C...'30
Baker, Norval E., 30 Rockefeller Plaza, Room 2824, New York, N. Y...'27
Baker, Raymond F., Geological Dept., The Texas Co., 135 E. Forty-Second St., New York, N. Y...'17
Baker, William A., Jr., Geological Dept., Huasteca Petr. Co., Apartado 94, Tampico, Tamps., Mexico...'24
||Bakke, W. E. Geological Dept., North Penn Gas Co., 206 Broad St., Port Allegany, Pa...'28
Baldwin, E. B., Arkansas Fuel Oil Co., 1802 Esperson Bldg., Houston, Tex...'29
Bale, Hubert E., 701 Continental Bldg., Oklahoma City, Okla...'24
Ball, Max W., 715 First Natl. Bank Bldg., Denver, Colo...'19
Ballard, James L., Box 2332, Houston, Tex...'25
||Ballard, William Norval, Phillips Petr. Co., Box 355, Saginaw, Mich...'29
Banks, Thomas R., Magnolia Petr. Co., 1704 Alamo Natl. Bldg., San Antonio, Tex...'27
Barbat, William F., Standard Oil Co., Taft, Calif...'28
Barlow, Victor, 121 N. Hill St., Los Angeles, Calif...'27
Barnes, Roy M., Continental Oil Co., 417 S. Hill St., Los Angeles, Calif...'24
||Barnes, Virgil E., 1815 Avenue I, Galveston, Tex. (Mail returned)...'31
Barnett, D. G., Geological Dept., United Production Corp., Houston, Tex...'25

Barnhart, Carl F., Gypsy Oil Co., Box 661, Tulsa, Okla. ... '29
Barnwell, George F., Ned. Kol. Petr. Mij., The Hague, Holland ... '28
‖Barragy, Edward J., Rockwell, Iowa ... '31
Barret, William M., 2524 Fairfield Ave., Shreveport, La. ... '32
Barrow, Leonidas T., 3314 Chevy Chase Drive, Houston, Tex. ... '22
Bartell, Laurence D., East Texas Refg. Co., Longview, Tex. ... '27
Bartle, Glenn G., University of Kansas City, Kansas City, Mo. ... '27
Bartlett, C. Lothrop, Sun Oil Co., Beaumont, Tex. ... '28
Bartlett, Fred W., Shell Petr. Corp., Shell Bldg., Houston, Tex. ... '24
Barton, Donald C., Humble Oil & Refg. Co., Box 2180, Houston, Tex. ... '20
Barton, Louis A., Box 433, Shreveport, La. ... '20
Bartram, John G., Stanolind Oil & Gas Co., Casper, Wyo. ... '17
Barwick, John S., 510 S. Pearl, Paola, Kan. ... '24
Bass, N. W., U. S. Geological Survey, Washington, D. C. ... '25
Bassett, Charles F., Hinckley, Ill. ... '28
Bassler, Harvey, c/o Samuel Mosser, Myerstown, Pa. ... '28
Bateman, Alan M., Yale University, Drawer 91-A, Yale Sta., New Haven, Conn. ... '20
‖Bates, R. P., 404 Springer Bldg., Tulsa, Okla. ... '30
Bauer, C. Max, Box 236, Yellowstone Park, Wyo. ... '17
Bauermann, Max K. H., Carel van Bylandtlaan 30, The Hague, Holland ... '27
Bauernschmidt, A. J., Magnolia Petr. Co., Box 872, Lake Charles, La. ... '27
‖Bay, Harry X., Cole Camp, Mo. ... '30
Bayer, H. M., Box 968, Midland, Tex. ... '25
Beal, Carl H., 650 S. Grand Ave., Los Angeles, Calif. ... '19
Bean, Ward C., Box 1191, Tulsa, Okla. ... '18
Beatty, Robert M., Box 239, Houston, Tex. ... '27
Beck, Elfred, 506 N. Quanah, Tulsa, Okla. ... '20
Beckelhymer, Roy L., 2235 Robinhood St., Houston, Tex. ... '26
Becker, Clyde M., 224 S. Fourteenth St., Chickasha, Okla. ... '21
Beckwith, H. T., 547 Subway Terminal Bldg., Los Angeles, Calif. ... '21
Beekly, Albert L., Box 381, Tulsa, Okla. ... '19
Beers, Roland F., 1311 Republic Bank Bldg., Dallas, Tex. ... '31
Behre, Charles H., Jr., Northwestern University, Evanston, Ill. ... '29
Belknap, Ralph L., University of Michigan, Ann Arbor, Mich. ... '31
Bell, Alfred H., State Geological Survey, Urbana, Ill. ... '28
Bell, Harry Wesley, Lion Oil Refg. Co., Exchange Bldg., El Dorado, Ark. ... '22
Bell, Olin G., Box 548, Laredo, Tex. ... '20
Belluigi, Arnaldo, Via Vitt. Em. 178, Parma, Italy ... '31
Belt, Ben C., 3451 Del Monte Drive, Houston, Tex. ... '19
Benedum, Darwin, 414 W. Elsmere Pl., San Antonio, Tex. ... '27
Bennett, Clyde M., Magnolia Petr. Co., Dallas, Tex. ... '18
‖Benson, Don G., Box 104, Greeley, Kan. ... '31
‖Benson, Edmund T., State Geological Survey, Urbana, Ill. ... '31
‖Benson, Floyd P., 121 E. Oklahoma, Blackwell, Okla. ... '31
Bentz, Alfred, Invalidenstr. 44, Berlin N. 4, Germany ... '34
Berger, Walter R., 1005 Fort Worth Natl. Bank Bldg., Fort Worth, Tex. ... '17
Bernard, W. E., Gypsy Oil Co., Box 661, Tulsa, Okla. ... '21
Bernoulli, W., 57 Sissacherstrasse, Basle, Switzerland ... '24
Berry, Hally L., Venezuelan Sun Co., Ltd., Apartado 34, Maracaibo, Venezuela, S. A. ... '27
Berwald, W. B., U. S. Bureau of Mines, Bartlesville, Okla. ... '23
Best, J. Boyd, Route 1, Box 420, Houston, Tex. ... '21
Bevier, George M., 609 Sterling Bldg., Houston, Tex. ... '21
Bickel, C. Russell, Shell Petr. Corp., Box 417, McPherson, Kan. ... '27
Bingham, Dwight H., c/o Bingham Clothing Co., Junction City, Kan. ... '21
‖Bingman, Neal J., Box 4, Midland, Tex. (Mail returned) ... '30
Biraud, F., Cie Francaise des Petroles, 9 Square de Messine, Paris, France ... '31
‖Birdsong, Peyton M., 1522 Grand Ave., Fort Worth, Tex. ... '30
Birk, Ralph A., 811 City Natl. Bank Bldg., Wichita Falls, Tex. ... '20
Birkhauser, Max, Shell Oil Co., Shell Bldg., Los Angeles, Calif. ... '26
‖Black, Jo Pat, 2365 Orange St., Beaumont, Tex. ... '32
‖Blackburn, Willis C., 1418 Nevada St., Houston, Tex. ... '28
Blackwelder, Eliot, Box N, Stanford University, Calif. ... '19

Blanchard, J. B., Marshall Hotel, Marshall, Tex. (Mail returned)..............'31
Blanchard, W. Grant, Jr., 3609 Potomac, Dallas, Tex..........................'18
Blanpied, B. W., Drawer 1731, Shreveport, La.................................'23
||Blau, Ludwig W., 2027 Colquitt, Houston, Tex...............................'30
Bleecker, Edward S., 1615 Whitehall Bldg., 17 Battery Pl., New York, N. Y.......'21
Blodget, Ward B., 707 Petroleum Securities Bldg., Tenth & Flower Sts., Los Angeles, Calif..'24
Bloesch, Edward, 840 Kennedy Bldg., Tulsa, Okla..............................'17
Bohart, Philip H., Gypsy Oil Co., Box 661, Tulsa, Okla.........................'23
Bohdanowicz, Charles, Str. Polna 64, Warsaw, Poland...........................'31
Bolyard, Garrett L., 515 Barrow St., Houma, La................................'27
||Bond, Marshall, 328 E. Islay St., Santa Barbara, Calif.......................'24
Boos, C. Maynard, Phillips Petr. Co., Bartlesville, Okla........................'26
Boos, E. J., Box 355, Saginaw, Mich...'27
Borden, Joseph L., Box 271, Tulsa, Okla.......................................'27
Borden, S. P., 721 Slattery Bldg., Shreveport, La..............................'24
Born, W. T., 2607 N. Boston Pl., Tulsa, Okla...................................'32
Bornhauser, Max, Superior Oil Co., 4614 Montrose Blvd., Houston, Tex.........'28
Borst, O. H., c/o Harris & Haun, Inc., Blackwell, Okla. (Mail returned)...........'28
Bossard, Leon, "Wharetui," Chemin de Vallauris, Antibes, A. M., France........'29
Bossler, Robert B., 102 Grant Court, Olean, N. Y..............................'21
Bostick, J. Wallace, 4648 Waneta Drive, Dallas, Tex............................'19
Bowen, Charles F., Standard Oil Co. of New Jersey, 30 Rockefeller Plaza, New York, N. Y...'20
Bowen, James P., Panhandle Refg. Co., Wichita Falls, Tex.......................'18
Bower, John O., Geological Dept., Calle Chile 778, Buenos Aires, Argentina, S. A...'29
Bowes, Glenn H., 731 Garfield Ave., S. Pasadena, Calif..........................'24
Bowman, Francis F., Jr., Cedarwood Farm, Madison, Wis.........................'29
Bowman, Wayne F., 1737 W. Main St., Houston, Tex.............................'19
Boyd, Harold, Henry Doherty & Co., 60 Wall St., New York, N. Y..................'17
||Boyd, W. Baxter, 1212 S. Fifth St., Ponca City, Okla...........................'29
Boyer, Will W., 401 Consolidated Royalty Bldg., Casper, Wyo.....................'28
Boylan, Ebert E., Caracas Petr. Corp., Apartado 587, Caracas, Venezuela, S. A...'19
Boyle, Albert C., Jr., Union Pacific System, 305 Custer St., Laramie, Wyo.........'23
||Boyle, George R., 1020 W. Twentieth St., Oklahoma City, Okla..................'20
Boyle, Walter J., 1721 W. Mistletoe, San Antonio, Tex...........................'26
||Boyles, James M., 3512 Travis St., Houston, Tex...............................'31
Brace, Orval L., 2104 Bissonett St., Houston, Tex...............................'19
||Bradfield, Herbert H., Geological Dept., Indiana University, Bloomington, Ind..'27
Bradish, Ford, 2005 Fort Worth Natl. Bank Bldg., Fort Worth, Tex.................'19
Bradley, Everett L., 600 Bitting Bldg., Wichita, Kan............................'22
Braendlin, Emil, Bataafsche Petr. Mij., Pangkalan Brandan, North Sumatra, D. E. I..'32
Brainerd, Arthur E., Geological Div., Continental Oil Co., Denver, Colo...........'22
Bramlette, Milton N., U. S. Geological Survey, Washington, D. C..................'25
||Brankstone, Hugh R., 1256 McNeilly Ave., Pittsburgh, Pa.......................'32
Branner, George C., 447 State Capitol Bldg., Little Rock, Ark....................'21
Branson, E. B., University of Missouri, Columbia, Mo...........................'25
||Brasted, Fred, Jr., Stanolind Oil & Gas Co., Casper, Wyo.......................'30
Brant, Ralph A., Atlantic Oil Prod. Co., 510 Beacon Life Bldg., Tulsa, Okla........'26
Brantly, John E., 1003 First Natl. Bank Bldg., Dallas, Tex.......................'18
Brauchli, R. W., Anderson-Prichard Oil Corp., Colcord Bldg., Oklahoma City, Okla...'23
Braugh, Donald D., Sun Oil Co., 820 Esperson Bldg., Houston, Tex...............'21
Brehm, Ralph C., 1741 Bolsover, Houston, Tex..................................'27
||Breitenstein, Robert S., Geological Dept., Calle Chile 778, Buenos Aires, Argentina, S. A..'29
||Bremer, Bernhard E., Box 644, Hattiesburg, Miss...............................'30
Bremner, Carl St. J., 2320 State St., Santa Barbara, Calif.......................'23
||Brewer, Charles, Jr., 1 D Gibson Terrace, Cambridge, Mass......................'27
||Brian, J. Carl, Aspermont, Tex..'28
Brice, John W., Standard Oil Co. of Venezuela, Caripito, Venezuela, S. A..........'28
||Briggs, Robert C., Jr., 417 West Bldg., Houston, Tex...........................'32

Brill, Virgil A., Box 938, McCamey, Tex. '33
Brillhart, Norman W., Box 654, Madill, Okla. '28
Briscoe, Glenn O., Hotel Goodhue, Port Arthur, Tex. '22
Brockway, E. R., 407 N. Seventh St., Marshall, Ill. '24
Brokaw, Albert D., Parsonage Hill Rd., Short Hills, N. J. '22
||Brooks, Olin D., 5807 Prospect Ave., Dallas, Tex. '30
Broomfield, R. A., Jr., 912 Petroleum Securities Bldg., Los Angeles, Calif. '28
||Broughton, M. N., Box 317, Camden, Ark. '33
||Brown, Arthur B., 1727 Baker St., Bakersfield, Calif. '31
Brown, E. Call, 4445 Gainsborough Ave., Los Angeles, Calif. '23
Brown, Harry J., 640 W. Fourteenth St., Tulsa, Okla. '25
Brown, Ira Otho, 1416 Milam Bldg., San Antonio, Tex. '24
Brown, J. Earle, 1305 Madeline Pl., Fort Worth, Tex. '20
Brown, J. Marshall, Venezuela Gulf Oil Co., Apartado 234, Maracaibo, Venezuela, S. A. '25
Brown, James Chapman, Blairfordel, 31 Balgreen Rd., Edinburgh, Scotland '27
||Brown, Merritt H., Darby Petr. Corp., 507 Philcade Bldg., Tulsa, Okla. '29
||Brown, Otto E., 614 S. Monroe, Stillwater, Okla. '31
Brown, Prentice F., Box 776, Midland, Tex. '29
Brown, Robert, 2107 Blodgett, Houston, Tex. '30
Brown, Robert Wesley, Dept. of Geology, St. Lawrence University, Canton, N. Y. '20
Brown, Samuel B., Ford, Bacon & Davis, Inc., 39 Broadway, New York, N. Y. '29
||Brown, William F., 304 S. Main St., Mt. Pleasant, Mich. '30
Browning, Iley B., Box 126, Ashland, Ky. '21
Brucks, E. W., 354 Cavalier Ave., San Antonio, Tex. 24
||Brunner, Michael C., 1008 W. Sixth St., Los Angeles, Calif. '29
Bruyere, Alan, Box 1160, Fort Worth, Tex. '19
Bryant, Howard S., Skelly Oil Co., Ellis Singleton Bldg., Wichita, Kan. '27
Buchanan, George S., Adams Louisiana Corp., 2302 Esperson Bldg., Houston, Tex. '25
Buchner, Carl F., 2101 Missouri Pacific Bldg., 1226 Olive St., St. Louis, Mo. '26
Buck, E. O., Box 1428, Amarillo, Tex. '27
Buckstaff, Sherwood, Shell Petr. Corp., Box 1191, Tulsa, Okla. '27
Buddenhagen, H. J., 392 S. Coronado, Ventura, Calif. '31
Buehler, H. A., Rolla, Mo. '21
Bullard, Edgar F., Box 591, Tulsa, Okla. '23
Bullard, Fred M., Dept. of Geology, University of Texas, Austin, Tex. '20
Bunte, Arnold S., Shell Petr. Corp., Greenwich, Kan. '26
Burchfiel, Hugh L., 1710 Hills Ave., Tampa, Fla. '23
Burford, Selwyn O., 1133 Weaver St., Houston, Tex. '26
||Burger, Robert W., 1338 N. Columbus Ave., Glendale, Calif. '30
Burling, Lancaster D., 1060 Grant Pl., Boulder, Colo. '24
Burnett, Jerome B., Lago Petr. Corp., Apartado 172, Maracaibo, Venezuela, S. A. '18
||Burnett, T. J., Box 598, Tyler, Tex. '30
Burress, Walter M., Box 727, Tyler, Tex. '20
Burt, Frederick A., A. and M. College, College Station, Tex. '32
Burt, Roy A., Fifty-Sixth & Shawnee Mission Rd., Kansas City, Kan. '20
||Burton, Waldo E., Mountain Park, Okla. '30
Bush, Frederic A., 2145 N. Elwood, Tulsa, Okla. '31
Butcher, Cary P., Box 331, San Angelo, Tex. '24
Butler, Frank H., Box 20, Douglass, Tex. '28
Butt, William H., Apartado 10, Matanzas, Cuba '32
Buttermore, Paul M., 1025 S. Adams St., Fort Worth, Tex. '27
Butterworth, E. M., Ned. Pac. Petr. Mij., Batavia, Java, D. E. I. '21
Buttram, Frank, 2909 First Natl. Bank Bldg., Oklahoma City, Okla. '18
Buttram, William A., Route 2, Puente, Calif. '22
Buwalda, John P., California Inst. of Technology, Pasadena, Calif. '26
Buzzo, Thomas W., 1655 Harrold St., Houston, Tex. '23
Bybee, Hal P., 805 San Angelo Natl. Bank Bldg., San Angelo, Tex. '19
Byrd, David Harold, 1108 Tower Petroleum Bldg., Dallas, Tex '27

Cadle, Austin, Room 1523, Standard Oil Bldg., San Francisco, Calif. '25
||Cadman, A. Denys, N-13 Lowell House, Cambridge, Mass. '31
Callahan, Drury V., c/o Westheimer & Daube, Ardmore, Okla. '26

||Calohan, William F., 1819 Guadalupe, Laredo, Tex. . . . . '31
Camp, Richard W., Box 1439, Oklahoma City, Okla. . . . . '30
Campbell, Ian, Dept. of Geology, California Inst. of Technology, Pasadena, Calif. . . '26
||Campbell, John M., Box 278, Laredo, Tex. . . . . '31
Campbell, Keir A., Eastsound, Wash. . . . . '32
Campbell, Robert B., 220 Alta Ave., San Antonio, Tex. . . . . '23
Cannon, Joe, 901 Western Reserve Bldg., San Angelo, Tex. . . . . '28
Cannon, R. L., 901 Western Reserve Bldg., San Angelo, Tex. . . . . '23
||Cardwell, D. Harold, Sun Oil Co., Box 1118, Kilgore, Tex. . . . . '30
Carlson, Charles G., Peerless Oil & Gas Co., 702 Natl. Bank of Commerce Bldg., Tulsa, Okla. . . . . '24
Carlson, Edwin N., 612 Bitting Bldg., Box 552, Wichita, Kan. . . . . '24
Carlton, Dave P., Humble Oil & Refg. Co., Houston, Tex. . . . . '20
Carney, Frank, Box 397, B. U. Sta., Waco, Tex. . . . . '21
||Carpenter, E. Gail, Phillips Petr. Co., 610 Ellis Singleton Bldg., Wichita, Kan. . . . . '26
Carpenter, Everett, 2214 Ong St., Amarillo, Tex. . . . . '21
||Carpenter, Margaret C., 1305 E. Magnolia, Fort Worth, Tex. . . . . '27
Carr, George W., Geophysical Dept., Shell Petr. Corp., Box 2099, Houston, Tex. . . '26
||Carrell, Olleon, Godley, Tex. . . . . '28
Carsey, J. Ben., Box 938, McCamey, Tex. . . . . '26
Carson, Carlton M., Box 101, Cupertino, Santa Clara County, Calif. . . . . '27
||Carson, R. E. L., 2910 Fannin, Houston, Tex. . . . . '30
||Carter, Devere V., Box 413, Greggton, Tex. . . . . '28
Cartwright, Lon D., Jr., Fisher & Lowrie, 713 Esperson Bldg., Houston, Tex. . . . . '24
Case, Leslie C., Gypsy Oil Co., Box 661, Tulsa, Okla. . . . . '26
Case, William B., Shell Petr. Corp., Drawer 36, St. Louis, Mo. . . . . '22
||Cash, Thornton C., Humble Oil & Refg. Co., Tyler, Tex. . . . . '23
Cashin, D'Arcy M., 3403 Yoakam Blvd., Houston, Tex. . . . . '19
Cassel, Chester, 5328 Abbott Pl., Los Angeles, Calif. . . . . '30
Cassingham, Robert L., 506 American Natl. Bank Bldg., Enid, Okla. . . . . '27
Casteel, S. H., Box 2077, Fort Worth, Tex. . . . . '30
Caster, E. L., Arkansas Nat. Gas Corp., Shreveport, La. . . . . '28
Caudill, Samuel J., 1504 Philtower Bldg., Tulsa, Okla. . . . . '19
Cave, Harold S., Box 2097, Denver, Colo. . . . . '23
Chapin, Theodore, Apartment Hotel Cissna, Bellingham, Wash. . . . . '23
Charles, Homer H., Box 1251, Bartlesville, Okla. . . . . '25
Charlton, Frances, Pure Oil Co., Houston, Tex. . . . . '32
Charrin, P., 30 Rue Fabert, Paris, VII, France . . . . '28
Chase, James L., 217 Flower St., Costa Mesa, Calif. . . . . '22
Chawner, William D., 874 Adelaide Drive, Pasadena, Calif. . . . . '29
Cheney, M. G., Coleman, Tex. . . . . '19
Cheney, Robert B., Box 660, Tyler, Tex. . . . . '28
Chevalier, Jerome A., 510 Exchange Bank Bldg., Tulsa, Okla. . . . . '25
Cheyney, Alvin E., 536 S. Lorraine, Wichita, Kan. . . . . '21
Childerhose, Allen J., The Texas Co., 408 Sherman Bldg., Corpus Christi, Tex. . . . . '30
||Christensen, H. E., Box 2420, Tulsa, Okla. (Mail returned) . . . . '29
Christie, Laurence G., Shell Petr. Corp., Box 2099, Houston, Tex. . . . . '25
||Christie, Robert S., Amerada Petr. Corp., Route 6, Longview, Tex. . . . . '25
Christner, D. D., 2121 Mistletoe Ave., Fort Worth, Tex. . . . . '24
||Christner, J. B., Box 232, Rockdale, Tex. . . . . '28
||Church, Charles R., Jr., 217 W. Walnut St., Titusville, Pa. . . . . '31
Church, Clifford C., 79 New Montgomery St., San Francisco, Calif. . . . . '30
Clapp, F. G., 50 Church St., New York, N. Y. . . . . '18
Clark, Bruce L., Hearst Mining Bldg., University of California, Berkeley, Calif. . . . '27
Clark, Chester C., 412 Pierre Mont Rd., Shreveport, La. . . . . '19
Clark, Clare M., 1531 S. Twenty-Fifth St., Lincoln, Neb. . . . . '28
Clark, Clifton W., 719 City Natl. Bank Bldg., Wichita Falls, Tex. . . . . '19
Clark, Frank Rinker, Box 981, Tulsa, Okla. . . . . '20
Clark, Frank T., The Empire Companies, Bartlesville, Okla. . . . . '23
Clark, Glenn C., Continental Oil Co., Ponca City, Okla. . . . . '19
Clark, George H., Box 336, Livingston, Tex. . . . . '33
Clark, Howard, Reserve Petr. Co., Philcade Bldg., Tulsa, Okla. . . . . '23
Clark, H. Smith, Box 1990, Fort Worth, Tex. . . . . '22

||Clark, John W., Box 971, Oklahoma City, Okla....'27
Clark, Joseph M., Gypsy Oil Co., Box 661, Tulsa, Okla....'29
Clark, Leslie M., Shell Oil Co., 1008 W. Sixth St., Los Angeles, Calif....'26
Clark, L. W., 1719 Milam Bldg., San Antonio, Tex....'29
Clark, Robert P., 2309 Bissonett, Houston, Tex....'27
Clark, Robert W., 2236 Almont St., Carrick, Pittsburgh, Pa....'18
Clark, Stuart K., Continental Oil Co., Ponca City, Okla....'19
Clark, William A., Jr., Box 24, Livingston, Tex....'26
Clark, William L., Kessler Oil & Gas Co., Petroleum Bldg., Oklahoma City, Okla..'25
Classen, Willard J., Associated Oil Co., Room 435, 79 New Montgomery St., San Francisco, Calif....'23
Clawson, William W., 3115 Mocking Bird Lane, Dallas, Tex....'25
||Clay, Withers, 519 Third Ave., Hibbing, Minn....'26
Clifford, O. C., Jr., Geophysical Dept., Continental Oil Co., Ponca City, Okla....'28
Clifton, R. L., Box 1123, Enid, Okla....'25
Cline, Justus H., Stuarts Draft, Va....'20
Clinkscales, Albert S., 804 Colcord Bldg., Oklahoma City, Okla....'19
Clopton, John H., 1601 Milam Bldg., San Antonio, Tex....'30
Closuit, E. M., 703 Browder St., Dallas, Tex....'22
Clowe, Charles E., 118 W. Main St., Ardmore, Okla....'23
||Coates, George H., Plaza Hotel, San Antonio, Tex....'26
Cobb, Margaret C., 124 E. Eighty-Fourth St., New York, N. Y....'26
Cochran, Phil K., Carter Oil Co., 707 Bitting Bldg., Wichita, Kan....'23
Coffin, R. Clare, Stanolind Oil & Gas Co., Tulsa, Okla....'26
Cole, Edwin, 1510 E. Broadway, Enid, Okla....'25
Cole, Virgil B., 211 S. Center, Ada, Okla....'24
Coleman, Bond, Mound City, Kan....'25
Coleman, Don P., 3223 E. English, Wichita, Kan....'32
Coleman, Tom L., Box 124, Wichita Falls, Tex....'24
Collingwood, D. M., Sun Oil Co., Box 2880, Dallas, Tex....'21
Collins, C. Philip, 702 S. Second St., McAlester, Okla....'25
Collom, Roy E., Continental Oil Co., 417 S. Hill St., Los Angeles, Calif....'19
Colton, Earl G., Okmulgee, Okla....'29
Condit, D. Dale, 11,140 Montana Ave., W. Los Angeles, Calif....'21
Conkling, R. A., 804 Colcord Bldg., Oklahoma City, Okla....'17
Conkling, Russell C., 2421 Kingston Drive, Houston, Tex....'22
||Conners, Thomas P., 414 Bellefontaine, Kansas City, Mo. (Mail returned)....'30
||Conrad, Charles S., Esperson Bldg., Houston, Tex....'29
Cook, Carroll E., 5829 Hurst St., New Orleans, La....'22
Cook, Harold J., Agate, Neb....'20
Cooper, Herschel H., 1015 Milam Bldg., San Antonio, Tex....'25
Copass, Jack M., 1601 S. Jenkins, Norman, Okla....'27
Copeland, Richard G., 1212 S. Broadway, Tyler, Tex....'27
Copelin, Leonard S., 607 Richfield Oil Bldg., Los Angeles, Calif....'30
Corbett, Clifton S., Gulf Oil Co., Room 1646, 17 Battery Pl., New York, N. Y....'19
Corby, Grant W., Box 514, Arcadia, Los Angeles Co., Calif....'26
||Cordry, C. D., Gulf Production Co., Box 1290, Fort Worth, Tex....'29
||Corey, William Henry, 2706 Prospect Ave., La Crescenta, Calif....'32
||Cornell, Lee H., 413 First Natl. Bank Bldg., Wichita, Kan....'27
Cortes, Henry C., Magnolia Petr. Co., Box 111, Houston, Tex....'30
Coryell, Horace N., Columbia University, New York, N. Y....'26
Coryell, Lewis S., 339 W. Fifth St., Bristow, Okla....'20
||Coryn, F. R., The Texas Co., Box 2332, Houston, Tex....'30
Cotner, Victor, Box 1141, Amarillo, Tex....'27
Cottingham, Virgil E., Box 474, San Angelo, Tex....'21
||Courtier, William H., Kinsley, Kan....'28
Cox, Benjamin Burton, Room 417, 26 Broadway, New York, N. Y....'26
Cox, Thomas S., Box 589, Beeville, Tex....'28
||Craft, Benjamin C., Louisiana State University, Baton Rouge, La....'30
Craig, Eric K., 1234 Ethel St., Glendale, Calif....'28
||Craig, T. C., Phillips Petr. Co., Amarillo, Tex....'31
Cram, Ira H., 1729 S. Cincinnati, Tulsa, Okla....'26
Crandall, Kenneth H., Box C, Alice, Tex....'23

Crandall, Richard R., 945 Schumacher Drive, Los Angeles, Calif. '24
Crandall, Roderic, 17 Battery Pl., New York, N. Y. '24
Cranson, Lorin A., 215 Market St., San Francisco, Calif. '29
Crawford, David J., 3251 Culver St., Dallas, Tex. '27
Crebbs, Chester M., Apartado 234, Maracaibo, Venezuela, S. A. '22
Crider, Albert F., 821 Ontario St., Shreveport, La. '22
Croneis, Carey, Walker Museum, University of Chicago, Chicago, Ill. '29
Crook, Theo H., c/o W. B. Thomas, 6699 Telegraph Ave., Oakland, Calif. '24
||Crosby, Arthur S., 4213 Clinton, Los Angeles, Calif. '28
||Crotty, James W., Box 217, Safford, Ariz. '27
Crum, Harry E., Columbian Carbon Co., Charleston, W. Va. '23
Cruse, John S., Jr., Amerada Petr. Corp., Houston, Tex. '26
Cullen, Ronald J., Twin State Oil Co., Tulsa, Okla. '23
Culver, Harold E., State College of Washington, Pullman, Wash. '24
Cumming, Alfred, Box 11-A, Route 1, Bixby, Okla. '24
Cunningham, Carleton J., Box 548, Laredo, Tex. '29
Cunningham, George M., 2735 Stuart St., Berkeley, Calif. '24
Curry, William H., Jr., 2618 Kingston Drive, Houston, Tex. '28
Curtice, A. Arthur, 435 A. G. Barlett Bldg., 215 W. Seventh St., Los Angeles, Calif. '24
||Cushing, John W., Wiser Oil Co., Bartlesville, Okla. '30
Cushman, Joseph A., 76 Brook Rd., Sharon, Mass. '24
Cutler, Willard W., Jr., 1729 N. Canyon Drive, Los Angeles, Calif. '17
Cuyler, Robert H., Dept. of Geology, University of Texas, Austin, Tex. '29

||Dahl, Arnold C., Wolverine Petr. Corp., Box 219, Avant, Okla. '34
||Dahlgren, Elmer George, 536 W. Hill St., Oklahoma, City, Okla. '32
Dake, Charles L., 1106 Main St., Rolla, Mo. '27
Dallmus, Karl F., Cia de Petr. Mercedes S. A., Apartado 94, Tampico, Tamps., Mexico '28
Dally, Claude F., 4120 Mattison, Fort Worth, Tex. '20
Damon, Gordon, University Station, Box 1561, Austin, Tex. '29
Dana, Drexler, Box 138-A, R. 1, La Cumbre Rd., Santa Barbara, Calif. '27
Dana, P. L., Gypsy Oil Co., Box 661, Tulsa, Okla. '30
Daniels, James I., Continental Oil Co., Ponca City, Okla. '24
Dannenberg, R. M., Shell Petr. Corp., St. Louis, Mo. '25
Darke, Roy E., 2004 Truxtun, Bakersfield, Calif. '27
Darnell, James L., 945 President St., New York, N. Y. '22
||Darnell, James L., Jr., 420 Lexington Ave., New York, N. Y. '28
||Dashti, Abdullah Khan, Geological Dept., Anglo-Persian Oil Co., Ltd., Masjed-i-Suleiman, Persian Gulf, Persia '33
||Davidson, John P., 618 Hamilton Bldg., Wichita Falls, Tex. '33
Davies, Fred A., Bahrein Petr. Co., Ltd., Bahrein Islands, Persian Gulf '20
Davies, Herman F., 342 Conoco Bldg., Denver, Colo. '27
||Davies, Nathan C., Coudersport, Pa. '29
Davies, Stanley J., 1128 Prospect Ave., Calgary, Alta., Canada '31
||Davis, Charles A., Estimating Div., Arizona State Highway Dept., Phoenix, Ariz. '27
Davis, Donald M., Pure Oil Co., Houston, Tex. '26
Davis, Elmer Fred, Shell Oil Co., 614 Shell Bldg., 1008 W. Sixth Ave., Los Angeles, Calif. '21
||Davis, Field M., 904 Wilkinson St., Shreveport, La. '31
Davis, Morgan J., Ned. Kol. Petr. Mij., Batavia, Java, D. E. I. '26
Davis, Ralph E., 1710 Union Bank Bldg., Pittsburgh, Pa. '19
Davis, Robert J., Shell Petr. Corp., Drawer 8, St. Louis, Mo. '21
Davis, Thornton, Simms Oil Co., 612 Alamo Natl. Bldg., San Antonio, Tex. '25
||Dawson, Edwin A., The Texas Co., Box 1801, Wichita, Kan. '30
Dawson, Joseph M., 1432 Milam Bldg., San Antonio, Tex. '23
Dawson, William A., 1508 Classen Blvd., Oklahoma City, Okla. '26
Day, Clarence O., Phillips Petr. Co., Drawer B, Bartlesville, Okla. '20
||Day, James R., Amerada Petr. Corp., Box 832, San Angelo, Tex. '30
Dean, D. P., W. T. Waggoner Bldg., Fort Worth, Tex. '19
Dean, P. C., W. T. Waggoner Bldg., Fort Worth, Tex. '19
Decius, L. Courtney, Associated Oil Co., 79 New Montgomery St., San Francisco, Calif. '19

de Cizancourt, Henry, Compagnie francaise des Petroles, 9 square Messine, Paris, 8, France....'29
*Decker, Charles E., 508 Chautauqua Ave., Norman, Okla....'17
||Decker, LaVerne, Box 692, Houston, Tex....'27
de Cousser, Kurt H., 201 Dean Apts., 727 N. Capitol Ave., Lansing, Mich....'27
DeFord, Ronald K., Box 475, Roswell, N. Mex....'25
DeGolyer, E., Room 1457, 120 Broadway, New York, N. Y....'17
||Delehanty, R. V., 39 E. Fourth St., Mt. Vernon, N. Y....'31
Denison, A. R., Box 1348, Fort Worth, Tex....'21
||Deputy, P. R., The Texas Co., Room 1003, 929 S. Broadway, Los Angeles, Calif..'30
Deussen, Alexander, 1606 Shell Bldg., Houston, Tex....'17
DeWolf, Frank W., Dept. of Geology, University of Illinois, Urbana, Ill....'20
Dickerson, Roy E., Apartamento 107, Edificio Lopez Serrano, Havana, Cuba....'25
Dickinson, George, 18 Frederick Road, Wylde Green, Birmingham, England,....'33
||Dietert, Arthur E., Empire Oil & Refg. Co., Box 468, Lyons, Kan....'31
Dille, Glenn Scott, Box 912, Tulsa, Okla....'28
||Dinsmoor, Carlton G., Moran, Tex....'32
Disney, Orville A., General Delivery, Sedan, Kan....'20
Dixon, A. Faison, 37 Clifford Ave., Pelhamwood, N. Y....'19
Doane, George H., Room 604, 1709 W. Eighth St., Los Angeles, Calif....'26
Dobbin, Carroll E., 523 Custom House, Denver, Colo....'22
Dodge, John F., Div. of Petroleum Eng., University of California, Los Angeles, Calif....'24
Dodson, Floyd C., 208 S. Park St., San Angelo, Tex....'23
Doering, John, 1401 Tower Petroleum Bldg., Dallas, Tex....'30
||Donnelly, Alden Stuart, Box 776, Midland, Tex....'30
Donoghue, David, 1116 Fort Worth Natl. Bank Bldg., Fort Worth, Tex....'18
Donovan, Percy W., 1701 Foshay Tower, Minneapolis, Minn....'19
Dorchester, Charles M., Gulf Refg. Co., Box 1731, Shreveport, La....'19
Dorr, James B., Shell Petr. Corp., Box 2099, Houston, Tex....'25
Dorrance, James R., 18 Flower St., Bakersfield, Calif....'26
Dorsey, Geo. Edwin, Box 904, Dallas, Tex....'24
Dott, Robert H., 904 Atlas Bldg., Tulsa, Okla....'18
Douglas, James M., 1108½ Brent St., S. Pasadena, Calif....'23
Douglas, John G., Box 606, Chapel Hill, N. C....'27
Dovre, Adolph, 128 E. Magnolia Ave., San Antonio, Tex....'22
Doyle, John J., Humble Oil & Refg. Co., Box 233, Lake Charles, La....'24
||Dragusanu, J. B., 25, Rue Saussure, Paris, 17, France....'29
Drake, Cecil, Apartado 150, Tampico, Mexico....'29
||Drake, Lemuel Clyde, Box 403, Wellington, Tex....'31
Dreher, Otto, Ferdinandstrasse 27, Hannover, Germany....'21
||Dresbach, C. H., Gulf Research & Development Corp., 327 Craft Ave., Pittsburgh, Pa....'31
Dresser, Myron A., 912 Raton Ave., La Junta, Colo....'19
Driver, Herschel L., 630 W. Palm Drive, Glendale, Calif....'25
Duce, James Terry, c/o A. C. Hunter, The Texas Co., 135 E. Forty-Second St., New York, N. Y....'20
Dufour, Jan, Caribbean Petr. Corp., Maracaibo, Venezuela, S. A....'30
Dunlevy, Robert B., 302 College St., Winfield, Kan....'21
Durkee, Robert R., Dixie Oil Co., 1704 Milam Bldg., San Antonio, Tex....'28
Durward, Robert Harland, 710 W. Rosewood Ave., San Antonio. Tex....'26
Duston, Arthur W., Box 1681, Tulsa, Okla....'21

Eagles, Homer M., Standard Oil Co. of New Jersey, Tax Dept., 30 Rockefeller Plaza, New York, N. Y....'22
||Earl, Eugene L., Box 112, Kilgore, Tex....'33
Eaton, Joseph E., 2058 N. Sycamore Ave., Los Angeles, Calif....'25
Eby, J. Brian, Box 962, Houston, Tex....'25
||Eckenwiler, Cleo, 507 Philcade Bldg., Tulsa, Okla....'32
Eckert, Frank E., c/o Hanley & Bird, Bradford, Pa....'21
Eckhardt, E. A., 1520 Shady Ave., Pittsburgh, Pa....'30
||Ekholm, Victor E., 610 Fort Worth Natl. Bank Bldg., Fort Worth, Tex....'28
Edson, Dwight J., 1507 Esperson Bldg., Houston, Tex....'22

Edson, Fanny C., Shell Petr. Corp., Box 1191, Tulsa, Okla. .... '22
Edwards, Everett C., Vista, Calif. .... '23
Edwards, Merwin G., Shell Oil Co., 1008 W. Sixth St., Los Angeles, Calif. .... '25
Eirich, Constance G., Gypsy Oil Co., Box 661, Tulsa, Okla. .... '21
Elin, Nicolas D., State Oil Trust "Grozneft," Grozny, U. S. S. R. .... '31
Elledge, Emmett R., Box 857, Chickasha, Okla. .... '25
Elliott, George R., Black Diamond Hotel Bldg., Black Diamond, Alta., Canada .... '26
Elliott, John E., 4731 E. Fifty-Second Drive, Los Angeles, Calif. .... '19
Ellis, George L., 436 S. Forty-Ninth St., Philadelphia, Pa. .... '24
Ellison, Charles W., 1201 N. Broadway, Shawnee, Okla. .... '30
Ellison, Kenneth A., 1025 First Natl. Bank Bldg., Oklahoma City, Okla. .... '28
Ellisor, Alva C., 305 Annex B, Humble Bldg., Houston, Tex. .... '21
Emendorfer, Earl, 35 Clark St., Brooklyn, N. Y. .... '27
Emery, Wilson B., 1041 S. Center St., Casper, Wyo. .... '23
Emmons, William H., University of Minnesota, Minneapolis, Minn. .... '19
Emrick, D. G., Drawer 2100, Houston, Tex. .... '28
Emrick, E. Byers, Box 496, Conrad, Mont. .... '22
Engel, Rene L. H., Dept. of Geology, Inst. of Technology, Pasadena, Calif. .... '25
Engleman, Rolf, 711 Juniper Lane, Norman, Okla. .... '25
English, Walter A., 601 W. Fifth St., Room 930, Los Angeles, Calif. .... '19
Erb, Josef T., van Dorpstr. 9, The Hague, Holland .... '24
Erdmann, Charles E., 523 Custom House, Denver, Colo. .... '30
Erni, Arthur, Landhaus Kully, Trimbach, Kt. Solothurn, Switzerland .... '21
Esary, Ralph E., 925 Hunter Ave., Bloomington, Ind. .... '32
Esgen, W. K., Humble Oil & Refg. Co., Houston, Tex. .... '29
||Eskrigge, Tatham R., Box 1214, Pittsburgh, Pa. .... '30
Estabrook, Edward L., 30 Rockefeller Plaza, Room 2769, New York, N. Y. .... '20
Etherington, Thomas, Richmond Petr. Co., Barranquilla, Colombia, S. A. .... '33
||Evans, Eugene P., Drawer 2040, Tulsa, Okla. .... '30
Evans, Frank G., Jr., Box 386, Teague, Tex. .... '28
||Evans, Louis H., 1950 Wellington Rd., Los Angeles, Calif. .... '24
Evans, Noel, 701 Continental Oil Bldg., Oklahoma City, Okla. .... '20
Eyoub, Djevad, Iktisat Vekaleti, Ankara, Turkey .... '26
Eyssell, Alfred R., 1105 Alamo Natl. Bldg., San Antonio, Tex. .... '25

||Fahmy, E. H., No. 5 Bateniah St., El Azhar, Cairo, Egypt .... '26
Farish, Linn M., Foreign Dept., Henry L. Doherty & Co., 60 Wall St., New York, N. Y. .... '28
||Farrell, Agnes M., 706 Harvard Hall, 1650 Harvard St., N. W., Washington, D. C. .. '26
Fash, Ralph H., Box 1379, Fort Worth, Tex. .... '27
Fath, A. E., Semperhaus B/III, Hamburg 1, Germany .... '17
||Faust, Joseph, 1215 N. Hudson St., Oklahoma City, Okla. .... '31
Faust, L. Y., Drawer 2040, Tulsa, Okla. .... '32
||Feagin, Barney, Jr., 330 Ritz Bldg., Tulsa, Okla. .... '30
Fenn, Ivan J., 809 Adams St., Amarillo, Tex. .... '29
Fergus, Preston, 400 Forsythe, Monroe, La. .... '27
Ferguson, John L., Drawer 2040, Tulsa, Okla. .... '20
Ferguson, Kenneth S., Box 2, San Angelo, Tex. .... '27
Ferguson, R. N., 549 Subway Terminal Bldg., 417 S. Hill St., Los Angeles, Calif. .. '19
||Ferrero, Clarence, Tidewater Oil Co., Esperson Bldg., Houston, Tex. .... '28
Fettke, Charles R., 1118 Wightman St., Pittsburgh, Pa. .... '20
||Fields, Harry B., Geophysical Dept., The Texas Co., Houston, Tex. .... '28
Finch, Elmer H., Auditorium Hotel, Houston, Tex. .... '22
Finch, John Wellington, Idaho Bureau of Mines & Geology, University of Idaho, Moscow, Idaho .... '24
Finley, J. C., Phillips Petr. Co., Box 152, Shawnee, Okla. .... '34
Fipps, E. L., 509 W. Sixteenth St., Joplin, Mo. .... '26
Fischer, Otto, Box 1375, Charleston, W. Va. .... '17
Fisher, D. J., Rosenwald Hall, University of Chicago, Chicago, Ill. .... '27
Fisher, Leslie A., Sinclair-Prairie Oil Co., Box 2411, Houston, Tex. .... '31
FitzGerald, James, Jr., Skelly Oil Co., Box 1485, Midland, Tex. .... '25
||Fitzgerald, Paul E., Dowell, Inc., Midland, Mich. .... '30
Flagler, C. W., Colombia Petr. Co., Cucuta, Colombia, S.A. .... '30

Floyd, Florin W., 1315 S. Guthrie, Tulsa, Okla. '23
||Fly, Paul J., 715 W. Pine St., Hattiesburg, Miss. '31
Fohs, F. Julius, Esperson Bldg., Houston, Tex. '17
Foley, Lyndon L., Box 981, Tulsa, Okla. '22
Folger, Anthony, Gypsy Oil Co., 1107 Union Natl. Bank Bldg., Wichita, Kan. '22
||Fonville, Herman A., 1515 Ninth St., Wichita Falls, Tex. '27
Foran, William T., General Ballivian FCCNA, Argentina, S. A. '31
Fortier, Leo R., Box 1400, Wichita, Kan. '25
Fortine, Dwight H., 536 W. One Hundred and Twelfth St., Los Angeles, Calif. '30
Fosdick, Arthur R., 706 Fort Worth Natl. Bank Bldg., Fort Worth, Tex. '32
Fossa-Mancini, Enrico, Direccion General Y. P. F., Paseo Colon 922, Buenos Aires, Argentina, S. A. '31
Fowler, George M., 314 Joplin Natl. Bank Bldg., Joplin, Mo. '23
||Fox, Ira William, 701 Oakland Ave., Greensburg, Pa. '27
||Fox, James P., Apartado 4, Puerto Mexico, Ver., Mexico '29
Fox, Leo S., General Petr. Corp., 1003 Higgins Bldg., Los Angeles, Calif. '27
Fralich, Charles E., Hooker-Fulton Bldg., Bradford, Pa. '25
Franklin, Louis, 1423 Marshall St., Houston, Tex. '20
||Franks, Robert M., Second Natl. Bank Bldg., Houston, Tex. '30
Freedman, L. H., 1402 Sinclair Bldg., Fort Worth, Tex. '22
Frei, Frederick, 7316 Lakewood Blvd., Dallas, Tex. '25
||Freie, A. J., Standard Oil Co. of Venezuela, Caripito, Venezuela, S. A. '28
Frey, Alfred P., Caribbean Petr. Co., Maracaibo, Venezuela, S. A. '24
Fritts, Harold M., Shell Petr. Corp., Box 362, Oakdale, La. '26
Fuellhart, Donald E., Natchitoches, La. '29
||Fulton, Loris J., 921 S. Eighth St., Chickasha, Okla. '29
||Funk, Fred J., Box 120, Casper, Wyo. '28
Funk, Marion H., Box 741, Gladewater, Tex. '24
Fuqua, H. B., Box 1290, Fort Worth, Tex. '20
Fyfe, Douglas, 215 W. Seventh St., Los Angeles, Calif. '20

Gaddess, Jack, North Pennsylvania Gas Co., Port Allegany, Pa. '25
Gahring, William Ross, Box 520, Shawnee, Okla. '25
Galbraith, T. J., 315 W. Huisache, San Antonio, Tex. '20
||Gale, Hoyt Rodney, 1775 Hill Drive, Eagle Rock, Los Angeles, Calif. '29
||Galley, John E., Shell Petr. Corp., Box 1191, Tulsa, Okla. '29
Galloway, J. J., Dept. of Geology, University of Indiana, Bloomington, Ind. '25
Galloway, John O., Box 750, Coalinga, Calif. '21
Galpin, Sidney L., Dept. of Geology, West Virginia University, Morgantown, W. Va. '19
||Gardner, A. Maclay, 455 E. Ocean Ave., Cooper Arms Apts., Long Beach, Calif. '30
Gardner, James H., 326 Beacon Life Bldg., Tulsa, Okla. '17
Gardner, Julia, U. S. Geological Survey, Washington, D. C. '27
Garfias, Valentine R., Henry L. Doherty & Co., 60 Wall St., New York, N. Y. '19
Garlough, J. L., 331 N. Fountain Ave., Wichita, Kan. '28
Garner, Aubrey H., 256 S. Mountain Ave., Montclair, N. J. '19
Garnjost, Frederick W., Spuyten Duyvil, New York, N. Y. '21
Garrett, Lovic P., 4301 Rossmoyne Blvd., Houston, Tex. '18
Garret, Melvin M., 208-9 City Natl. Bldg., Wichita Falls, Tex. '21
Garrett, Robert E., 533 Beacon Life Bldg., Tulsa, Okla. '21
||Garst, Jarvis, Apartado 209, Monterrey, N. L., Mexico '31
Gaylord, E. G., 225 Bush St., San Francisco, Calif. '20
Gealy, Wendell B., 3306 Iowa St., Pittsburgh, Pa. '26
Geis, Wilfrid H., 985 San Pasqual St., Pasadena, Calif. '23
George, W. O., 606 Eighth Ave., Laurel, Miss. '24
Germany, E. B., 724 Fidelity Bldg., Dallas, Tex. '26
Gester, George C., 1129 Standard Oil Bldg., San Francisco, Calif. '20
Gester, Stephen H., 1128 Standard Oil Bldg., San Francisco, Calif. '21
Getzendaner, A. E., 831 Nixon Bldg., Corpus Christi, Tex. '24
Getzendaner, Frank M., Uvalde, Tex. '21
Gevaerts, E. A. L., Caribbean Petr. Co., Maracaibo, Venezuela, S. A. '28
||Gibbs, Harley S., 416 Zara St., Pittsburgh (10), Pa. '30
Gibbs, James F., Panhandle Refg. Co., Box 1107, Wichita Falls, Tex. '27

Giddings, Harvard, 149 Seventh St., Fon du Lac, Wis. .... '26
Gierhart, Guy B., Box 548, Laredo, Tex. .... '28
Giles, Albert W., Dept. of Geology, University of Arkansas, Fayetteville, Ark. .... '22
Giles, John M., 5367 Wingohocking Terrace, Germantown, Pa. .... '26
Gillan, Silas L., 230 Webb Drive, Glendale, Calif. .... '26
Gillespie, Bartlett W., 108 S. El Molino, Alhambra, Calif. .... '27
Gillson, Joseph L., 1007 Market St., Room 8063, Wilmington, Del. .... '30
Gilmour, Andrew, Drawer 2040, Tulsa, Okla. .... '29
Ginter, Roy L., 118 W. Cameron St., Tulsa, Okla. .... '33
Gish, Wesley G., Sinclair-Prairie Oil Co., Box 1990, Fort Worth, Tex. .... '22
Glenn, L. C., 2111 Garland Ave., Nashville, Tenn. .... '19
Goblot, Henri, 3 Rue Andrieux, Paris, France .... '29
Goldston, Walter L., Jr., 718 Esperson Bldg., Houston, Tex. .... '20
Goldstone, Frank, Shell Petr. Corp., Box 2099, Houston, Tex. .... '30
Goodman, P. W., Box 188, Cement, Okla. .... '31
*Goodrich, Harold B., 1628 S. Cincinnati, Tulsa, Okla. .... '18
||Goodrich, Paul K., Sun Oil Co., Box 2880, Dallas, Tex. .... '30
Goodrich, Raymond H., 2117 Gulf Bldg., Houston, Tex. .... '24
Goodrich, Robert D., 706 Fort Worth Natl. Bank Bldg., Fort Worth, Tex. .... '18
||Goodwill, Donald, Jr., 304 Ward Bldg., Shreveport, La. .... '31
Gordon, Dugald, Suite 2426, Gulf Bldg., Houston, Tex. .... '22
Gordon, Wallace, 1037 Kennedy Bldg., Tulsa, Okla. .... '20
Goubkin, I. M., Leontievsky per. 25 Kw. 14, Twerskaya, Moscow, U. S. S. R. .... '32
Goudkoff, Paul P., 1204 Subway Terminal Bldg., Los Angeles, Calif. .... '25
Gouin, Frank, Box 72, Duncan, Okla. .... '19
Gould, Charles N., Oklahoma Geological Survey, Norman, Okla. .... '17
||Gould, Don B., Dept. of Geology, Cornell College, Mt. Vernon, Iowa .... '28
Gow, Kenneth L., Box 33-B, R. F. D. 5, Bakersfield, Calif. .... '31
||Grage, Victor P., Drawer 1731, Shreveport, La. .... '30
||Graham, B. L., Empire Oil & Refg. Co., Masonic-Empire Bldg., Bartlesville, Okla. .. '29
Graham, William A. P., Dept. of Geology, Ohio State University, Columbus, Ohio .. '29
Graham, W. L., Route 2, Orlando, Okla. .... '29
Grant, Paul A., Columbus, Mont. .... '23
||Grant, U. S., IV, Dept. of Geology, University of California, Los Angeles, Calif. .. '32
Gray, Alfred, 4112 Gaston Ave., Dallas, Tex. .... '20
Gray, Shapleigh G., The Texas Co., Box 1737, Shreveport, La. .... '28
Gray, William D., Box 2168, Tulsa, Okla. .... '27
Green, Darsie A., 320 E. Keith St., Norman, Okla. .... '25
Green, Guy E., 710 W. Russell Pl., San Antonio, Tex. .... '24
Green, William G., 709 Kennedy Bldg., Tulsa, Okla. .... '33
Greene, Frank C., 1434 S. Cincinnati, Tulsa, Okla. .... '17
Greene, Ray G., Route 1, Box 531, San Jose, Calif. .... '20
||Gregory, J. N., Box 243, San Angelo, Tex. .... '30
Greig, Douglas A., c/o Thos. Cook & Son (Bankers) Ltd., Head Office, Berkeley St., Piccadilly, London, W. 1, England .... '30
Gretzinger, William, 636 Hastings, St., Pittsburgh, Pa. .... '20
Griffith, Cunningham L., Alleyton, Tex. .... '22
Griffith, Glenn R. V., 400 Fair Oak St., Little Valley, N. Y. .... '28
Grigsby, Garland O., 1836 Irving Pl., Shreveport, La. .... '28
Grigsby, R. B., Stanolind Oil & Gas Co., 1001 Louisiana Natl. Bank Bldg., Baton Rouge, La. .... '24
Griley, Horace L., Twin State Oil Co., Box 1348, Tulsa, Okla. .... '24
Grim, Ralph E., 804 S. First St., Champaign, Ill. .... '27
Grimes, Glenn, Wirt Franklin Petr. Corp., Box 898, Oklahoma, City Okla. .... '29
Grimes, Russell W., Shell Petr. Corp., St. Louis, Mo. .... '27
Grimm, Maurice W., 203 Ward Bldg., Shreveport, La. .... '25
Grinsfelder, Sam, 803 N. Washington, Victoria, Tex. .... '24
Griswold, Clyde T., 1500 Las Lomas Road, Albuquerque, N. Mex. .... '18
Grogan, Samuel A., Apartado 106, Tampico, Mexico .... '24
||Gude, Leo J., 1005 Tradesmen's Bank Bldg., Oklahoma City, Okla. .... '30
||Guerrero, Alberto Lobo-, Apartado 666, Bogota, Colombia, S. A. .... '31
Guinn, Delmar R., Empire Gas & Fuel Co., Roswell, N. Mex. .... '29
Gulley, M. Gordon, c/o K. C. Heald, Box 1214, Pittsburgh, Pa. .... '25

Gunby, Merle F., Box 222, Laredo, Tex. '24
||Gunn, James E., 116 W. Kaufman St., Paris, Tex. '33
Gunter, Herman, 715 E. Virginia St., Tallahassee, Fla. '21
Gutenberg, Beno, Seismological Laboratory, 220 N. San Rafael Ave., Pasadena, Calif. '31
Gutzwiller, Otto, Bremgarten, Aargau, Switzerland '28

||Haas, Carl J., General Delivery, Overton, Tex. '29
||Haas, Johann Otto, M P Pen A. E. F., Port Gentil, Afrique Equatorial Francaise. '31
Hafner, W., Shell Petr. Corp., Box 1168, Bakersfield, Calif. '26
Hagan, Arthur M., Box 1456, Corpus Christi, Tex. '25
Hagan, E. F., 816 Monongahela Bldg., Morgantown, W. Va. '27
Hageman, Donald E., 525 Clark Ave., Billings, Mont. '23
||Hagen, Cecil Vernon, Feltex Oil Corp., Gulf Bldg., Houston, Tex. '31
Hager, Dilworth S., 335 Milam Bldg., San Antonio, Tex. '22
Hager, Dorsey, Dawson, Ky. '19
Hager, Lee, 1521 Esperson Bldg., Houston, Tex. '18
Hagy, Lawrence R., 706 Amarillo Bldg., Amarillo, Tex. '25
||Hahn, Raymond R., Barnes, Warren County, Pa. '23
Haight, Harold W., Apartado 94, Tampico, Tamps., Mexico '27
Hake, Benjamin F., 515 Lougheed Bldg., Calgary, Alta., Canada '26
||Halbouty, Michel T., Yount-Lee Oil Co., Beaumont, Tex. '31
Hall, Dollie Radler, Amerada Petr. Corp., Drawer 2040, Tulsa, Okla. '21
Hall, Ellis A., Box 211, Abilene, Tex. '25
Hall, Elwin B., 640 Title Insurance Bldg., Los Angeles, Calif. '24
Hall, Roy H., 270 S. Delrose, Wichita, Kan. '18
Halse, G. W., British Controlled Oilfields, Ltd., Siparia P. O., Palo Seco, Trinidad, B. W. I. '28
||Halsted, Morris E., Neils-Esperson Bldg., Room 1811, Houston, Tex. '30
Hamill, James M., Box 1640, Station C, Los Angeles, Calif. '29
Hamilton, C. E., 1916 N. Drexel, Oklahoma City, Okla. '28
Hamilton, Charles W., 17 Battery Pl., Sixteenth Floor, New York, N. Y. '20
Hamm, W. Dow, Shell Petr. Corp., Box 2099, Houston, Tex. '22
||Hamman, John, Jr., 2006 Gulf Bldg., Houston, Tex. '30
Hammer, Alva A., 2231 Idlewild, Abilene, Tex. '21
Hammill, Chester A., 1418 First Natl. Bank Bldg., Dallas, Tex. '17
||Hammond, Weldon W., Box 1238, Kilgore, Tex. '31
||Hancock, Bob, 121 N. D St., Yale, Okla. '30
Hancock, J. M., Geological Dept., United Production Corp., Beeville, Tex. '31
||Hancock, Ray A., R. D. 1, Box 462, Fullerton, Calif. '30
||Hancock, William T., Jr., 406 Marshall St., Houston, Tex. '30
Hanna, G. Dallas, California Academy of Sciences, San Francisco, Calif. '24
Hanna, Marcus A., 2910 Arbor, Houston, Tex. '25
Hanson, Perry R., Box 2033, Wichita, Kan. '27
||Hard, Edward W., 257 Bryant St., Buffalo, N. Y. '30
Hardison, George P., Shell Petr. Corp., Box 1191, Tulsa, Okla. '32
Hardy, Norman, Ned. Pac. Petr. Mij., Batavia, Java, D. E. I. '27
Hares, C. J., 305 Franklin St., Denver, Colo. '23
Harkness, R. B., Whitney Block, Parliament Bldgs., Toronto, Ont., Canada '24
||Harley, G. Townsend, Socorro, N. Mex. '33
Harlton, Bruce H., Amerada Petr. Corp., Drawer 2040, Tulsa, Okla. '27
Harnsberger, T. K., Sophian Plaza, Tulsa, Okla. '19
||Harrell, David C., Manuela Pedraza, Kilometer 1,400 FCCNA, Provincia de Salta, Argentina, S. A. '29
Harrell, Marshall A., U. S. Geological Survey, Washington, D. C. '27
Harrington, George L., Manuela Pedraza, FCCNA, Kilom. 1400, Provincia de Salta, Argentina, S. A. '24
Harrington, Rollin B., Box 848, Huntington, W. Va. '21
||Harris, Edwin S., 307 N. Main St., Henderson, Tex. '27
||Harris, R. W., Box 856, Norman, Okla. '26
Harrison, John Vernon, 34 Rowallan Gardens, Glasgow, W. 1, Scotland '31
Harrison, Thomas S., Box 324, Encinitas, Calif. '19
||Harriss, T. Fairman, Dept. of Geology, Pomona College, Claremont, Calif. '29

Hartley, Burton, 735 Milam Bldg., San Antonio, Tex. .... '17
Harvey, William W., 1022 Milam Bldg., San Antonio, Tex. .... '26
Haseltine, Raymond H., Box 2880, Dallas, Tex. .... '27
Hasselmann, Karl F., 1912 Esperson Bldg., Houston, Tex. .... '26
Hatcher, Oscar, Box 188, Ada, Okla. .... '27
‖Hatfield, Arlo C, Box S. S., Breckenridge, Tex. .... '31
Hawkins, Glenn D., Drawer I, Duncan, Okla. .... '28
Hawley, Henry J., 225 Bush St., San Francisco, Calif. .... '24
Hay, Lawrence C, 4329 E. English, Wichita, Kan. .... '21
Hayes, Albert O., Rutgers University, New Brunswick, N. J. .... '21
Haynes, Winthrop P., 68 Pall Mall, London, S. W. 1, England .... '17
Hazzard, Roy T., Gulf Refg. Co. of Louisiana, Shreveport, La. .... '25
Headley, Joseph B., Box 781, Roswell, N. Mex. .... '25
Heald, K. C., The Gulf Cos., Box 1214, Pittsburgh, Pa. .... '17
Heater, W. E., Ned. Pac. Petr. Mij., Batavia, Java, D. E. I. .... '31
Heath, Francis E., 4040 Hanover St., Dallas, Tex. .... '24
‖Heaton, Adrian H., 314 W. Second St., Carthage, Mo. .... '30
Heaton, R. L., 2374 Elm St., Denver, Colo. .... '20
Hedberg, Hollis D., Venezuela Gulf Oil Co., Apartado 234, Maracaibo, Venezuela, S. A. .... '26
‖Hedges, Kenneth P., 614 S. Elwood, Tulsa, Okla. (Mail returned) .... '29
Hedley, J. David, Jeffries Hotel, Thibodoux, La. .... '25
Hedrick, O. F., Texas Pacific Coal & Oil Co., Thurber, Tex. .... '23
Hegwein, Walter H., Cia. Mex. Pet. "El Aguila," Apartado 150, Tampico, Mexico .. '30
Heid, Gordon W., Ned. Kol. Petr. Mij., Weltevreden, Java, D. E. I. .... '27
Heidecke, Otto, Bakenstr. 2, Halberstadt, Germany .... '29
Heiland, Carl A., Colorado School of Mines, Golden, Colo. .... '28
Hemmings, H., Caribbean Petr. Co., Maracaibo, Venezuela, S. A. .... '27
‖Hemsell, Clenon C., Catarina Hotel, Catarina, Dimmit County, Tex. .... '33
Henbest, Lloyd G., Room 327, U. S. National Museum, Washington, D. C. .... '31
Henderson, Charles W., 519 Custom House, Denver, Colo. .... '25
Henderson, H. H., 414 Furr Drive, San Antonio, Tex. .... '24
‖Henderson, William David, Stanolind Oil & Gas Co., Shawnee, Okla. .... '29
Hendrickson, Victor J., 1703 Williams St., Denver, Colo. .... '23
‖Heninger, D. D., 1934 E. Houston St., San Antonio, Tex. .... '29
Henley, A. S., 401 Colquitt, Houston, Tex. .... '18
Hennen, Ray V., Box 675, Morgantown, W. Va. .... '19
Henniger, Waldemar F., 3355 Del Monte Drive, Houston, Tex. .... '18
Henning, John L., 525 Kirby St., Lake Charles, La. .... '19
Henny, Gerard, 620 S. Figueroa St., Los Angeles, Calif. .... '23
Henry, Leonard W., Apartado 93, Maracaibo, Venezuela, S. A. .... '30
Henry, Schuyler B., Bahrein Petr. Co. Ltd., Bahrein Islands, Persian Gulf, via Baghdad .... '25
Henson, F. R. S., P. O. Box 61, Baghdad, Iraq .... '32
Henson, G. R., Shell Petr. Corp., Box 2099, Houston, Tex. .... '24
Herald, Frank A., 2105 Fort Worth Natl. Bank Bldg., Fort Worth, Tex. .... '21
Herald, J. M., Cleo Springs, Okla. .... '17
Herold, Stanley C., 1330 Ethel St., Glendale, Calif. .... '19
Heroy, William B., Consolidated Oil Co., 45 Nassau St., New York, N. Y. .... '22
Herrick, Henry N., 1300 Standard Oil Bldg., San Francisco, Calif. .... '27
Hertel, Francis W., Box R, Ventura, Calif. .... '25
Heusser, H., Conde Penalver 15, Madrid, Spain .... '31
‖Hickey, Harold N., 816 First Natl. Bank Bldg., Great Falls, Mont. .... '24
Hiestand, Thomas C., W. C. McBride, Inc., 604 Wright Bldg., Tulsa, Okla. .... '25
Higgs, Morton T., 820 Esperson Bldg., Houston, Tex. .... '24
Hill, Harry B., 551 Federal Bldg., Dallas, Tex. .... '26
*Hill, Robert T., Hotel Commodore, Los Angeles, Calif. .... '19
Hill, V. G., Stanolind Oil & Gas Co., Box 814, Enid, Okla. .... '28
Hillis, Donuil, 728 S. New Hampshire St., Los Angeles, Calif. .... '26
Hindes, E. P., Henry L. Doherty & Co., 60 Wall St., New York, N. Y. .... '17
Hinds, Henry, Room 2749, 420 Lexington Ave., New York, N. Y. .... '19
Hlauschek, H., Nabr. legii 10, Prague, 16, Czechoslovakia .... '30
Hockman, James M., c/o G. P. Halsted, Guthrie, Okla. .... '24

Hodson, Floyd, Standard Oil Co. of Venezuela, Caripito, Venezuela, via Trinidad, B. W. I. '25
||Hodson, Helen K., Standard Oil Co. of Venezuela, Caripito, Venezuela, via Trinidad, B. W. I. '27
Hoekstra, Jean A., Labor Vincit, Voorburg, Holland '27
||Hoenshell, David T., Box 120, Coalinga, Calif. '26
Hoffman, Charles C., 705 New Masonic Bldg., Bartlesville, Okla. '20
Hoffman, Malvin G., Box 5, Pullman, Wash. '21
Hoffmann, Charles R., Mission d'etudes de recherches petrolieres, Maintirano, Madagascar '27
Hoffmeister, William S., Lago Petr. Corp., Apartado 172, Maracaibo, Venezuela, S. A. '28
Hogan, Dana, University Club, Los Angeles, Calif. '27
||Hoke, T. C., R. 4, Box 179-A, Lakeland, Fla. '29
Holden, Roy J., Polytechnic Inst., Blackburg, Va. '25
||Holland, Arthur J., Box 56, Kings Mill, Tex. '30
Holland, Laurier F. S., Bin F, Placerville, Calif. '27
||Hollingsworth, R. V., Box 297, Madill, Okla. '32
Holloman, Roy, c/o Max W. Ball, 425 First Natl. Bank Bldg., Denver, Colo. '21
Holman, Eugene, Room 2761, 30 Rockefeller Plaza, New York, N. Y. '20
Holman, W. H., 1415 S. Gramercy Pl., Los Angeles, Calif. '27
Holmes, S. W., Box 577, Capitol Hill Sta., Oklahoma City, Okla. '28
||Homer, George W., 1410 W. Lynwood Ave., San Antonio, Tex. '30
Honess, Charles W., 601 N. Pine St., Pauls Valley, Okla. '17
Hood, Forrest W., Cherokee, Okla. '28
||Hookway, L. C., Box 543, Moorpark, Calif. '30
Hoots, Harold W., Union Oil Co. of California, 1113 Union Oil Bldg., Los Angeles, Calif. '21
||Hoover, F. Mabry, Empire Oil & Refg. Co., Box 1163, Oklahoma, City Okla. '27
||Hoover, James B., 439 S. Hillside, Wichita, Kan. '29
Hoover, J. Wilkinson, Bahrein Petr. Co., Bahrein Islands, Persian Gulf '28
Hoover, William B., Box 668, Pampa, Tex. '25
Hopkins, Edwin B., 1307 First Natl. Bank Bldg., Dallas, Tex. '18
Hopkins, Oliver B., Imperial Oil Co., 56 Church St., Toronto, Ont., Canada '21
Hopper, Walter E., Box 1280, Shreveport, La. '20
||Hornberger, Joseph, Jr., Producing Dept., The Texas Co., Box 2332, Houston, Tex. '30
Horton, Harold M., 504 Esperson Bldg., Houston, Tex. '26
Hoskins, Baker, Jr., Box 291, Beeville, Tex. '26
Hosterman, John F., Box 832, San Angelo, Tex. '25
Housh, C. N., Gulf Production Co., Box 311, Longview, Tex. '24
||Houston, Sam H., Jr., 2015 Smith-Young Tower, San Antonio, Tex. '31
Howard, Arthur Henry, St. Helen's Court, Leadenhall St., London, E. C. 3, England '24
||Howard, Dan O., 209 E. Thirteenth St., Oklahoma City, Okla. '28
||Howard, Edward L., Box 334, Tyler, Tex. '33
Howard, William M., Box 374, Dixon, Calif. '29
Howard, W. V., Dept. of Geology, University of Illinois, Urbana, Ill. '29
Howe, Henry V., Dept. of Geology, Louisiana State University, Baton Rouge, La. '23
Howell, J. V., 300 N. Fourth St., Ponca City, Okla. '17
Howeth, Irving K., Plaza Hotel, San Antonio, Tex. '26
Hoyle, Charles R., 3004 N. W. Nineteenth St., Oklahoma City, Okla. '23
Hoyt, William V., 1851 Columbia St., Houston, Tex. '21
||Hruby, Milton, 217 N. Park Ave., Buffalo, N. Y. '30
||Hubbard, Allen F., Box 579, Long Beach, Calif. '29
Hubbard, Bela, Carter Oil Co., Box 801, Tulsa, Okla. '27
Hubbard, William E., Humble Oil & Refg. Co., McCamey, Tex. '19
Hubbert, M. K., Dept. of Geology, Columbia University, New York, N. Y. '28
||Hubman, Carl W., c/de Ultramar S. A. P. A., 778 Calle Chile, Buenos Aires, Argentina, S. A. '29
Hudnall, James S., Box 740, Tyler, Tex. '27
Hudson, Frank S., 1625 Opechee Way, Glendale, Calif. '23
Hudson, William A., 1810 Electric Bldg., Fort Worth, Tex. '26

Hughes, Richard, Box 268, Tulsa, Okla. '19
‖Hughes, Richard V., 1417 Sixteenth St., Auburn, Neb. '30
Hughes, Urban B., Eastman, Gardner & Co., Laurel, Miss. '20
Hulin, Carlton D., 1711 Central Ave., Alameda, Calif. '25
Hull, J. P. D., 2506 N. Cheyenne Ave., Tulsa, Okla. '20
Hume, George S., Geological Survey of Canada, Ottawa, Ont., Canada '27
Hummel, E. W., 1819 Walnut St., Abilene, Tex. '18
Hunt, Edwin H., Box 2100, Denver, Colo. '24
Hunter, Campbell M., 4 London Wall Bldgs., London, E. C. 2, England '27
Hunter, Coleman D., 608 Second Natl. Bank Bldg., Ashland, Ky. '30
Hunter, Dresden B., 245 N. Oliver St., Wichita, Kan. '25
Hunter, Harry M., 1419 Ninth St. W., Calgary, Alta., Canada '28
Hunter, James W., Standard Oil Co. of Venezuela, Caripito, Venezuela, via Trinidad, B. W. I. '27
Hunter, Paul B., Shell Petr. Corp., Box 2099, Houston, Tex. '24
‖Hunter, R. E. L., 1221 N.E. Euclid, Oklahoma City, Okla. '31
Huntley, Louis G., 2811 Grant Bldg., Pittsburgh, Pa. '19
Hupp, John Ervin, c/o L. B. O'Neil, Cut Bank, Mont. '26
Hutcheson, R. Bellenden, 2022 W. Seventy-Fourth St., Los Angeles, Calif. '28
Hutchinson, Frederick M., 410 Avondale Ave., Houston, Tex. '24
Hutson, E. B., Geological Dept., Standard Oil Co., Shreveport, La. '24
Hyde, Clarence E., 3628 Watonga Ave., Fort Worth, Tex. '23
Hynes, Dibrell P., 80 E. Jackson, Chicago, Ill. '24

Ickes, E. L., 10463 Tennessee Ave., W. Los Angeles, Calif. '24
Iddings, Arthur, International Pet. Co., Ltd., Talara, Peru, S. A. '19
Iki, Tsunenaka, Mining Dept., Imperial University of Tokyo, Tokyo, Japan '24
Ilsley, Ralph, 1200 Massachusetts Ave. 24 E., Cambridge, Mass. '27
Imbt, Robert F., 1520 Paseo de Vaca, San Angelo, Tex. '23
‖Imbt, William C., State Geological Survey, Urbana, Ill. '31
‖Ingham, W. I., 921 Nineteenth St., Golden, Colo. '28
Irwin, Joseph S., 3026 Glencoe Rd., Calgary, Atla., Canada '19
‖Irwin, Wallace W., Box 127, Midland, Tex. '30
Israelsky, Merle C., United Gas Corp., Box 2492, Houston, Tex. '25
Ivy, John Smith, United Gas Public Service Co., Box 2492, Houston, Tex. '25

Jablonski, Eugene, Taranaki Oil Fields N. L., Box 9, Gisborne, New Zealand '27
James, Wright E., 505 Cornell St., Palo Alto, Calif. '25
Jay, Stanley E., 307 N. Adams St., San Angelo, Tex. '24
Jeffreys, Geoffrey, 80 Maiden Lane, New York, N. Y. '26
Jenkins, J. H., Associated Oil Co., 79 New Montgomery St., San Francisco, Calif. '24
Jenkins, Olaf P., 630 Amherst St., Palo Alto, Calif. '28
Jennings, Charles I., Box 64, Laredo, Tex. '24
Jenny, W. P., 2102 Bissonett, Houston, Tex. '26
Jensen, Joseph, 766 Pacific Electric Bldg., Los Angeles, Calif. '23
‖Joekel, Fred E., 5945 Palo Pinto St., Dallas, Tex. '29
Johnson, E. L., 1308 Fort Worth Natl. Bank Bldg., Fort Worth, Tex. '29
‖Johnson, George V., 1300 Standard Oil Bldg., San Francisco, Calif. '30
Johnson, Harry R., 838 Roosevelt Bldg., Los Angeles, Calif. '23
‖Johnson, Henry L., U. S. Engineers, Rock Island, Ill. '30
Johnson, J. Harlan, Box 336, Golden, Colo. '24
Johnson, Russell V., 917 Lancaster Bldg., Calgary, Alta., Canada '20
Jones, Boone, 300 S. Mississippi, Ada, Okla. '21
Jones, Daniel J., 146 Bassett Ave., Lexington, Ky. '28
Jones, David Glynn, Compania Terrocarrilera de Petroleo, Km. 8, Comodoro Rivadavia, R. Argentina, S.A. '30
Jones, Edward L., Jr., Box 345, Scottsdale, Ariz. '22
‖Jones, Jess R., Box 5, Lookeba, Okla. '30
Jones, Ogden S., Texoma Nat. Gas Co., Fourth Floor Rule Bldg., Amarillo, Tex. '29
Jones, Robert L., Empire Gas & Fuel Co., Tyler, Tex. '25
Jones, Roy D., 812 E. Sixteenth St., Oklahoma City, Okla. '23
‖Jones, Wayne V., Box 582, Shreveport, La. '33
Judson, Sidney A., 3783 Carlon St., Houston, Tex. '24
Jung, Jean, 2 rue Boussaingault, Strasbourg, France '29

||Junger, Arne, Box 132, Hanford, Calif. '30
Just, Evan, New Mexico School of Mines, Socorro, N. Mex. '23
Justice, Philip S., Sun Oil Co., Drawer 790, Beaumont, Tex. '22

Kalb, J. L., Lago Petr. Corp., Apartado 172, Maracaibo, Venezuela, S. A. '33
Kamb, Hugo R., 2215 Russell Ave. N., Minneapolis, Minn. '27
Kane, William G., Apartado 134, Saltillo, Coahuila, Mexico '26
Karcher, John C., 4004 Euclid Ave., Dallas, Tex. '31
Kaseltiz, Fritz, Bornhausen am., Harz, Germany '30
Kauenhowen, Walter, Deutsche Vacuum Oel A. G., Semperhaus B/III, Hamburg, Germany '28
Kaufmann, Godfrey, Huasteca Petr. Co., Apartado 94, Tampico, Tamps., Mexico '25
Kautz, Archie R., Box 2404, Amarillo, Tex. '20
Kay, Fred H., Standard Oil Co. of New Jersey, 26 Broadway, New York, N. Y. '19
Kay, G. Marshall, Dept. of Geology, Columbia University, New York, N. Y. '29
Keeler, Clifton M., 406 N. W. Thirty-Third St., Oklahoma City, Okla. '19
Keeler, William W., 701 Atlas Life Bldg., Tulsa, Okla. '24
Keen, C. D., 529 Robinson Pl., Shreveport, La. '32
Kehrer, L., B. P. M., Tjepoe, Java, D. E. I. '30
||Keim, Roy E., 3019 Wabash Ave., Kansas City, Mo. '31
Keith, Arthur, 2210 Twentieth St., Washington, D. C. '29
Keller, P. Hastings, 628 S. Elmwood Ave., Oak Park, Ill. '26
Keller, Walter T., North Venezuelan Petr. Co. Ltd., Puerto Cabello, Venezuela, S. A. '27
Kelly, Ward W., Carrier No. 109, San Antonio, Tex. '29
Kellum, Lewis B., University Museums, University of Michigan, Ann Arbor, Mich. '25
||Kelsey, Martin C., Geophysical Service, Inc., 1311 Republic Bank Bldg., Dallas, Tex. '34
||Kemnitzer, Luis E., 1201 E. California St., Pasadena, Calif. '29
||Kemp, Augusta H., Box 626, Seymour, Tex. '26
Kendrick, Frank E., Lone Star Gas Co., Dallas, Tex. '20
Kennard, Harry C., Pennsville, Ohio '30
||Kennedy, Gilbert R., Box 367, Longview, Tex. '30
Kennedy, J. B., 2814 W. Lowden, Fort Worth, Tex. '26
Kennedy, Luther E., 1735 S. Victor, Tulsa, Okla. '19
Keppler, Leo G., 1529 S. Owasso Ave., Tulsa, Okla. '21
||Kerbow, Russell B., Gulf Research & Development Corp., Drawer K, Oakland Sta., Pittsburgh, Pa. '30
Kernan, Thomas H., Box 776, Seminole, Okla. '20
Kerr, John B., Hawkins Bros., Foreman, Ark. '20
Kerr, Richard C., Continental Air Map Co., 114 S. Beaudry St., Los Angeles, Calif. '27
Kesler, L. W., 527 First Natl. Bank Bldg., Wichita, Kan. '19
Kew, W. S. W., Standard Oil Co., Box 1390, Station C, Los Angeles, Calif. '21
||Keyte, W. Ross, Geological Dept., Phillips Petr. Co., Bartlesville, Okla. '28
Kidd, Robert L., Box 468, Lyons, Kan. '26
||Kiess, Myron C., 1347 S. Indianapolis, Tulsa, Okla. '27
Kihlstedt, Folke H., 11734 Union Turnpike, Kew Gardens, New York, N. Y. '31
Kimball, E. B., 1810 Electric Bldg., Fort Worth, Tex. '27
Kimball, Kent K., 1805 W. Easton St., Tulsa, Okla. '22
King, Charles C., 804 Wright Bldg., Tulsa, Okla. '27
King, Philip B., U. S. Geological Survey, Washington, D. C. '25
King, Robert E., Box 427, Iowa City, Iowa '31
King, Vernon L., 427 N. Fuller Ave., Los Angeles, Calif. '23
Kinkel, John F., 324 N. Delrose, Wichita, Kan. '25
Kinkel, W. C., Box 728, San Angelo, Tex. '23
Kinney, Harry D., Research Dept., Chase Natl. Bank, 11 Broad St., New York, N. Y. '24
Kirby, Grady C., Box 169, Beeville, Tex. '19
Kirby, James M., 225 Bush St., San Francisco, Calif. '27
||Kirby, Louie C., Box 202, Gentry, Ark. '31
Kirk, Charles T., 512 Commercial Bldg., Tulsa, Okla. '17
Kirk, Howard M., Mexico-Texas Petrolene & Asphalt Co., Apartado 285, Tampico, Mexico '27

Kirkham, Virgil R. D., 1020 Owen, Saginaw, Mich. .... '30
Kisling, James W., Jr., Amerada Petr. Corp., Tyler, Tex. .... '27
Kister, Herbert H., 400 Masonic Bldg., Shawnee, Okla. .... '26
Kitchin, Walter, Iraq Petr. Co., Ltd., Kirkuk, Iraq .... '31
Kite, William C., 704 Braniff Bldg., Oklahoma City, Okla. .... '17
||Kittredge, Frank R., 656 N. Beard St., Shawnee, Okla. .... '27
Kittredge, M. B., 656 N. Beard St., Shawnee, Okla. .... '25
Klaus, Hellmut, 327 Craft Ave., Pittsburgh, Pa. .... '28
||Kleinpell, Robert M., Box 1131, Bakersfield, Calif. .... '29
Kleinpell, William D., Box 1131, Bakersfield, Calif. .... '25
Klingaman, George L., The California Co., Midland, Tex. .... '25
Klinger, Edgar D., 502 S. Adams St., San Angelo, Tex. .... '27
Kluth, Emil, c/o G. F. Getty, 1060 Subway Terminal Bldg., 417 S. Hill St., Los Angeles, Calif. .... '27
Knappen, Russell S., Box 661, Tulsa, Okla. .... '20
Kneale, William C., The Texas Co., Box 938, Fort Worth, Tex. .... '27
Knebel, G. Moses, Standard Oil Co. of Venezuela, Caripito, Venezuela, via Trinidad, B. W. I. .... '24
||Knight, J. Brookes, Dept. of Geology, Occidental College, Los Angeles, Calif. .... '31
Knight, Oliver B., Huasteca Petr. Co., Apartado 26 Bis., Mexico, D. F. .... '28
Kniker, Hedwig T., Alamo Natl. Bldg., San Antonio, Tex. .... '21
Knox, George L., Bin XX, Taft, Calif. .... '27
Knox, John K., Phillips Petr. Co., Bartlesville, Okla. .... '19
Knox, T. K., Tower Petroleum Bldg., Dallas, Tex. .... '29
Knutson, C. J., 1710 Union Bank Bldg., Pittsburgh, Pa. .... '27
Kobayashi, Giichiro, 310 Zoshigaya, Tokyo-fuka, Japan .... '25
Koch, Richard E., 30 Carel van Bylandtlaan, The Hague, Holland .... '28
Koch, Thomas W., Bin XX, Standard Oil Co., Taft, Calif. .... '25
Koenig, Ralph A., Box 548, Carlsbad, N. Mex. .... '32
Kolm, Robert N., Atlantic Oil Prod. Co., Magnolia Bldg., Dallas, Tex. .... '19
||Kornfeld, M. M., Box 1119, Houston, Tex. .... '27
Kraft, Philip, 14 Wall St., Room 1500, New York, N. Y. .... '27
Krampert, E. W., Box 1106, Casper, Wyo. .... '23
Kraus, Edgar, Box 566, Carlsbad, N. Mex. .... '20
Krejci, Karl, Dept. of Paleontology, Sun Yatsen University, Canton, China .... '31
Kridler, George M., Deep Rock Oil Corp., Atlas Life Bldg., Tulsa, Okla. .... '26
Kroenlein, George A., Box 22, Carlsbad, N. Mex. .... '22
Krueger, Max L., Western Gulf Oil Co., 1221 Subway Terminal Bldg., Los Angeles, Calif. .... '25
Kugler, Hans G., Trinidad Leaseholds, Ltd., Point-a-Pierre, Trinidad, B. W. I. .... '27
Kuiper, W. N., Van Zaeckstraat 49, The Hague, Holland .... '28
Kurtz, Robert G., Ohio Oil Co., Casper, Wyo. .... '31

La Croix, Morris F., 82 Devonshire St., Boston, Mass. .... '21
Ladd, Harry S., c/o R. S. Bassler, U. S. National Museum, Washington, D. C. .... '30
||Lafferty, Robert C., Jr., Box 1240, Charleston, W. Va. .... '30
Lahee, Frederic H., Box 2880, Dallas, Tex. .... '19
||Laiming, Boris G., Geological Dept., The Texas Co., 929 S. Broadway, Los Angeles, Calif. .... '28
Lake, Francis W., Union Oil Co., Sante Fe Springs, Calif. .... '24
Lamb, R. C., Barnsdall Oil Co., Box 97, Earlsboro, Okla. .... '28
Lambert, Gerald S., 1915 S. Gary St., Tulsa, Okla. .... '28
Lane, Alfred C., 22 Arlington St., Cambridge B, Mass. .... '24
Lang, W. B., U. S. Geological Survey, Washington, D.C. .... '25
LaPeire, George W., United Fuel Gas Co., Box 1256, Charleston, W.Va. .... '26
Larkin, Pierce, 1440 S. Norfolk, Tulsa, Okla. .... '23
Larsh, Walter W., 413 First Natl. Bank Bldg., Wichita, Kan. .... '25
LaRue, James E., Humble Refg. Co., Houston, Tex. .... '20
Laskey, G. E., 710 N. Vienna St., Ruston, La. .... '21
La Touche, John D., Sun Oil Co., Beaumont, Tex. .... '31
Lauer, A. W., 1235 East Thirtieth St., Tulsa, Okla. .... '21
Laughbaum, Graydon H., Sinclair-Prairie Oil Co., Box 518, Covington, Okla. .... '31
Laughlin, R. W., 727 N. E. Twentieth St., Oklahoma City, Okla. .... '23

Lavington, Charles S., 1914 Leyden St., Denver, Colo. . . . '24
Lawson, Andrew C., University of California, Berkeley, Calif. . . . '27
Lawton, Joe, 205 Ira Ave., San Antonio, Tex. . . . '27
||Lay, Henry C., Shell Petr. Corp., Iowa, La. . . . '30
||Lay, Roy L., The Texas Co., Box 2332, Houston, Tex. . . . '33
||Leach, Walter W., Groesbeck, Tex. . . . '31
Leavenworth, Paul B., Box 2100, Houston, Tex. . . . '26
Lebkicher, Roy, 225 Bush St., San Francisco, Calif. . . . '27
Lee, Clarence L., Wahoo, Neb. . . . '31
Lee, Lynn K., Pure Oil Co., 35 E. Wacker Drive, Chicago, Ill. . . . '28
Lee, Marvin, 800 Bitting Bldg., Wichita, Kan. . . . '17
Lee, Wallace, Box 446, Okmulgee, Okla. . . . '20
Lees, George M., Anglo-Persian Oil Co. Ltd., Britannic House, Finsbury Circus, London, E. C. 2, England . . . '31
Lehman, Roy P., Route 1, Box 42, Halstead, Kan. . . . '26
Lehner, Ernest J., Trinidad Leaseholds Ltd., Pointe-a-Pierre, Trinidad, B.W.I. . . . '29
Leibensperger, Raymond, Wassenaarscheweg 117, The Hague, Holland . . . '18
Leidhold, Clemens, Yacimiento Petr. Fiscal Chubut, Comodore Rivadavia, Chubut, Argentina, S. A. . . . '30
Leighton, Morris M., 305 Ceramics Bldg., Urbana, Ill. . . . '24
Leiser, J. B., Geological Dept., Box 1191, Tulsa, Okla. . . . '26
Lemley, G. C., Box 23, Mount Morris, Pa. . . . '21
Lepper, G. W., Burmah Oil Co. Ltd., Nyounghla, Magwe District, Upper Burma, India . . . '25
Lesniak, Stanislaw W., 2729 Fullerton Ave., Chicago, Ill. . . . '25
Lester, O. C., Jr., Geophysical Research Corp., Drawer 2040, Tulsa, Okla. . . . '29
Levorsen, A. Irving, Tidewater Oil Co., Esperson Bldg., Houston, Tex. . . . '19
Lewis, Frank E., 1316 S. David, San Angelo, Tex. . . . '21
Lewis, James O., 507 Commercial Bldg., Tulsa, Okla. . . . '19
Lewis, J. Volney, 6 Linden Pl., White Plains, N.Y. . . . '23
Lewis, J. Whitney, 5645 Gaston Ave., Dallas, Tex. . . . '23
Ley, Henry A., 2825 Sixth Ave., Fort Worth, Tex. . . . '19
Leyds, Louis W., Dedelstraat, 11, The Hague, Holland . . . '27
Liddle, R. A., Pure Oil Co., Box 1007, Fort Worth, Tex. . . . '20
Lieb, Victor E., 2027 Rosedale Ave., Houston, Tex. . . . '24
Lilienborg, B. A., 1012 N. Rockford, Tulsa, Okla. . . . '33
Lilley, Ernest R., 104 Graham Ave., Paterson, N.J. . . . '28
Lillibridge, Harry E., 1501 W. Oklahoma, Enid, Okla. . . . '28
Lincoln, B. W., Hamilton Hotel, Laredo, Tex. . . . '28
Lindeblad, E. E., Box 566, Little Rock, Ark. . . . '19
Lindtrop, Norbert, Trust "Sredasneft" Kokand (Usbekistan), U.S.S.R. . . . '26
Link, Theodore A., Geological Dept., Imperial Oil, Ltd., Calgary, Alta., Canada . . '21
Link, Walter K., Ned. Kol. Petr. Mij., Batavia-Centrum, Java, D.E.I. . . . '30
Littlefield, Max S., Box 661, Tulsa, Okla. . . . '31
Livingston, Noyes B., 2505 Sixth Ave., Fort Worth, Tex. . . . '26
Lloyd, Abe M., Box 1215, Shreveport, La. . . . '21
Lloyd, E. Russell, Box 1106, Midland, Tex. . . . '21
Lockett, J. R., 1654 Genessee Ave., Linden, Columbus, Ohio . . . '28
||Lockwood, R. P., Box 302, Prague, Okla. . . . '30
||Loetterle, Gerald J., 1130 S. Sixteenth St., Lincoln, Neb. . . . '33
Logan, Clarence Z., 704 Natl. Bank of Commerce Bldg., Tulsa, Okla. . . . '20
Logan, David M., Okmulgee, Okla. . . . '25
||Logie, Russell Moore, Peabody Museum, New Haven, Conn. . . . '31
||Lohman, Mary Kathryn, c/o K. E. Lohman, U. S. Geological Survey, Washington, D.C. . . . '31
||Lokman, Kemal, Ministry of Economy, Mining Dept., Ankara, Turkey . . . '31
Long, Carl T., Hillman-Long, Inc., 1052 Subway Terminal Bldg., Los Angeles, Calif. . . . '25
Longmire, William R., 1107 Union Natl. Bank Bldg., Wichita, Kan. . . . '20
||Longnecker, Oscar M., Jr., 307 Southern Pacific Bldg., Houston, Tex. . . . '26
Lonsdale, John T., College Station, Tex. . . . '29
Loomis, Harve, Box 1344, Abilene, Tex. . . . '17
||Lott, Frederick S., 20 MacKay Place, Brooklyn, N.Y. . . . '30

Louderback, George D., University of California, Berkeley, Calif. '25
Lounsbery, D. E., Geological Dept., Phillips Petr. Co., Bartlesville, Okla. '21
Lovejoy, J. B., Gulf Production Co., Box 1290, Fort Worth, Tex. '27
Lovejoy, John M., Seaboard Oil Co. of Delaware, 30 Broadway, New York, N.Y. '24
Lovering, T. S., U. S. Geological Survey, Golden, Colo. '31
Low, Ian Campbell, 336 Reconquista, Buenos Aires, Argentina, S. A. '33
Lowman, Shepard W., Mid-Continent Petr. Corp., Box 2025, Tulsa, Okla. '26
||Lucke, John B., 110 Riverside Drive, New York, N.Y. '30
Lucky, M. C., 2007 Quenby Rd., Houston, Tex. '26
Luecke, Lester A., Colombian Petr. Co., Apartado 100, Cucuta, Colombia, S. A. '25
Lugn, A. L., Dept. of Geology, University of Nebraska, Lincoln, Neb. '31
Luman, Edmondson D., Atlantic Oil Prod. Co., Beacon Life Bldg., Tulsa, Okla. '24
Lund, Gage V., The California Co., Box 486, Victoria, Tex. '27
Lupton, Charles T., 617 Gilpin St., Denver, Colo. '20
Lynn, Robert H., Phillips Petr. Co., 507 Cherokee, Bartlesville, Okla. '21
Lynton, Edward D., Standard Oil Co. of California, Drawer V, Whittier, Calif. '23
Lyons, Richard T., Box 1650, Tulsa, Okla. '22
||Lytel, Harvey M., Box 202, Lost Hills, Calif. '28
||Lytle, J. Edward, Box 1349, Monroe, La. '31

MacDonald, Erwin H., 508 Securities Bldg., Billings, Mont. '23
MacDonell, James A., 632 W. Market St., Lima, Ohio '25
Macfadyen, William A., Ministry of Economics & Communications, Baghdad, Iraq. '25
MacKay, Hugh, 706 S. Poplar St., Sapulpa, Okla. '17
Mackenzie, Andrew N., Apartado 1706, Caracas, Venezuela, S. A. '22
MacNaughton, Lewis W., 1706 Esperson Bldg., Houston, Tex. '26
Macready, George A., 5425 Chesley Ave., Los Angeles, Calif. '19
Maddox, Gerald C., 2112 N. Villa, Oklahoma City, Okla. '29
Maddox, Walter H., Apartado 4, Puerto Mexico, Ver., Mexico '31
||Malamphy, Mark C., Instituto Geologico e Mineralogico do Brazil, Praia Vermelha, Rio de Janeiro, S. A. '30
Maley, Vaughn C., Humble Oil & Refg. Co., McCamey, Tex. '28
Maley, Willis A., 204 Nixon Bldg., Corpus Christi, Tex. '29
Manion, C. E., 1776 Krameria St., Denver, Colo. '27
Mannen, Richard Lee, 323 Bushnell Pl., San Antonio, Tex. '29
||Marie, Marcel, Geologue de la Cie Francaise des Petroles, à Maintirano, Madagascar '31
Markham, Edmond O., Carter Oil Co., Box 801, Tulsa, Okla. '20
Markley, Elmer A., Barnsdall Oil Co., Tulsa, Okla. '23
Markley, Joseph H., Jr., Box 600, Wichita Falls, Tex. '28
||Marr, John D., 2210 Esperson Bldg., Houston, Tex. '29
Marsters, Vernon F., Box 93, Princeton, Ky. '18
Marston, R. L., Box 23-A, Rio Grande City, Tex. '25
||Martin, B. G., Box 399, Crane, Tex. '30
Martin, Francis I., Apartado 263, Caracas, Venezuela, S. A. '23
Martin, George C., 503 N. Thirteenth St., Corvallis, Ore. '24
Martin, Helen M., 119 Genessee, Lapeer, Mich. '25
Martyn, Phillip F., Houston Oil Co. of Texas, Box 2412, Houston, Tex. '28
Mason, Shirley L., Venezuela Gulf Oil Corp., Apartado 35, Cuidad Bolivar, Venezuela, S. A. '19
Masterson, Reba B., Menger Hotel, San Antonio, Tex. '23
Mather, Kirtley F., Geological Museum, Oxford St., Cambridge, Mass. '21
Mathes, Donald E., 1818 Petroleum Bldg., Houston, Tex. '23
Matson, George C., 1534 E. Seventeenth Pl., Tulsa, Okla. '19
Matson, Martin, 2010 W. Summit, San Antonio, Tex. '25
Matteson, Wallace G., Box 376, Center Moriches, Long Island, N.Y. '18
Maucini, Joseph J., Geological Dept., Continental Oil Co. Wichita Falls, Tex. '27
Maverick, Phillip, Western Reserve Life Bldg., San Angelo, Tex. '23
||Maxwell, Riley G., Box 886, San Angelo, Tex. '30
May, Art R., 405 Haberfelde Bldg., Bakersfield, Calif. '21
May, John C., 122½ W. Figueroa, Santa Barbara, Calif. '33
McArthur, Donald, McHenry, Miss. '20
McAuliffe, G. C., Drawer 1346, Monroe, La. '32

||McCallum, Henry D., 2015 Smith-Young Tower, San Antonio, Tex. ... '31
||McCarter, W. Blair, Humble Oil & Refg. Co., Houston, Tex. ... '27
McCaskey, Morgan E., 3800 Monticello Drive, Fort Worth, Tex. ... '29
||McClain, Alan H., Geological Dept., United Fuel Gas Co., Charleston, W.Va. ... '32
McClellan, Hugh W., 616 N. Bluff St., Wichita, Kan. ... '27
McCloskey, Downs, 300 D St., Bakersfield, Calif. ... '33
McClure, J. H., Prairie Oil & Gas Co., Midland, Tex. ... '31
||McCobb, Harry W., Tropical Oil Co., Barranca-Bermeja, Colombia, S. A. ... '28
McCollom, C. R., 911 Richfield Bldg., 555 S. Flower St., Los Angeles, Calif. ... '23
McCollough, Edward H., 417 S. Hill St., Los Angeles, Calif. ... '24
McCollum, Leonard F., 2015 Smith-Young Tower, San Antonio, Tex. ... '27
||McCourt, James H., Montana Power Gas Co., Cut Bank, Mont. ... '33
McCoy, Alex. W., 919 E. Grand Ave., Ponca City, Okla. ... '17
McCrary, E. W., Box 861, Tulsa, Okla. ... '18
McCulloch, Joseph P., 275 Nassau St., Princeton, N.J. ... '26
McCullough, A. S., Clifton, Greene Co., Ohio ... '17
McCullough, R. L., Box 306, Great Bend, Kan. ... '25
McCune, Paul, 807 Burk Burnett Bldg., Fort Worth, Tex. ... '28
||McCutchin, John A., Shell Petr. Corp., Pampa, Tex. ... '28
McDermott, Eugene, 1311 Republic Bank Bldg., Dallas, Tex. ... '29
McDonald, Worth W., 1616 W. Kings Highway, San Antonio, Tex. ... '24
||McFarland, Earl R., Broadview Hotel, Oklahoma City, Okla. ... '30
McFarland, L. R., Box 4577, Capitol Hill Sta., Oklahoma City, Okla. ... '33
McFarland, Paul W., Box 2880, Dallas, Tex. ... '23
McFarland, R. S., 1002 First Natl. Bank Bldg., Dallas, Tex. ... '18
McFerron, George I., Adams Royalty Co., 2302 Esperson Bldg., Houston, Tex. ... '22
†McGaha, Charles P., 607 Hamilton Bldg., Wichita Falls, Tex. ... '29
McGee, D. A., Phillips Petr. Co., Drawer B, Bartlesville, Okla. ... '29
||McGehee, Rex, Shell Petr. Corp., Box 1191, Tulsa, Okla. ... '30
McGlothlin, Tom, 527 N. Douglass St., Shawnee, Okla. ... '29
McGlothlin, William C., 2121 Fourth Ave., Corsicana, Tex. ... '31
||McGowan, F. H., Box 193, Smithville, Tex. ... '29
||McIntyre, George T., 408 N. Delaware, Butler, Mo. ... '30
McIntyre, Paul J., 702 Natl. Bank of Commerce Bldg., Tulsa, Okla. ... '19
McKanna, Edwin A., 801 Columbia St., S. Pasadena, Calif. ... '21
||McKay, A. E., Phillips Petr. Co., Bartlesville, Okla. ... '30
McKee, H. Harper, Room 1457, 120 Broadway, New York, N.Y. ... '17
McKenna, John S., 4731 E. Fifty-Second Drive, Los Angeles, Calif. ... '26
McLaren, Robert L., 1415 Washington Ave., Golden, Colo. ... '27
McLellan, Hiram J., Humble Oil Co., Box 598, Tyler, Tex. ... '20
McLeod, Angus, Shell Petr. Corp., Shell Bldg., Houston, Tex. ... '19
McMillan, Joseph M., Jr., 2109 Avenue P, Galveston, Tex. ... '27
McNutt, Vachel H., 101 W. Summit, San Antonio, Tex. ... '21
McQueen, Henry S., Missouri Geological Survey, Rolla, Mo. ... '33
McWhirt, Burr, Shell Petr. Corp., Box 2099, Houston, Tex. ... '18
Mead, Roy G., 1220 Chapman Bldg., Los Angeles, Calif. ... '31
||Mechling, George W., 1995 Park Ave., Lincoln, Neb. ... '32
Meents, Richard O., 831 E. Main St., Ada, Okla. ... '33
Meland, Norman, 707 Braniff Bldg., Oklahoma City, Okla. ... '22
Mellen, William P., 4846 Tennyson St., Denver, Colo. ... '31
Mendenhall, Walter C., U. S. Geological Survey, Washington, D.C. ... '22
Menke, John H., 225 Bush St., San Francisco, Calif. ... '29
Menken, Fred A., Associated Oil Co., San Francisco, Calif. ... '32
Merritt, Floyd C., 4731 E. Fifty-Second Drive, Los Angeles, Calif. ... '23
Merritt, Roy W., 80 Broad St., Twenty-Eighth Floor, New York, N.Y. ... '29
Merry, Edward T., Box 868, San Angelo, Tex. ... '25
Mershon, Milton M., 1204 S. Braden, Tulsa, Okla. ... '25
||Metcalf, Myron C., c/o W. M. Streeter, Huntsville, Tex. ... '30
Metcalf, Roy J., 1415 Milam Bldg., San Antonio, Tex. ... '26
||Metts, Dean F., Humble Oil & Refg. Co., Roanoke, La. ... '34
Meyer, Arthur M., 906 Central Bldg., Wichita, Kan. ... '21
||Michaux, Frank W., Jr., 2419 Southmore Blvd., Houston, Tex. ... '31
Milek, Andrew, Mexican Sinclair Petr. Corp., Apartado 241, Tampico, Mexico ... '22

Millard, William J., 4224 Hastings St., El Paso, Tex. '19
||Miller, Albert Douglas, Dept. of Conservation, 304 Ward Bldg., Shreveport, La. '30
Miller, Carroll C., 734 Nixon Bldg., Corpus Christi, Tex. '25
Miller, David B., 1336 Gaylord St., Denver, Colo. '29
Miller, Forrest J., Arkansas Fuel Oil Co., Box 283, Houston, Tex. '22
Miller, Guy E., 205 Professional Bldg., Long Beach, Calif. '25
||Miller, Harry A., Box 122, Crescent, Okla. '28
Miller, John C., The Texas Co., Houston, Tex. '28
Miller, Milward, Humble Oil & Refg. Co., Roswell, N. Mex. '33
Miller, Robert P., Jubail, Sandi Arabia via Baghdad and Bahrein. '28
Miller, Wendell Z., 942 Kennedy Bldg., Tulsa, Okla. '21
Miller, Willard L., 2647 W. Fifteenth St., Oklahoma City, Okla. '19
||Miller, William C., Box 43, Golden, Colo. '31
Miller, William Dana, Apartado 478, Caracas, Venezuela, S. A. '31
Millikan, C. V., Drawer 2040, Tulsa, Okla. '20
Millison, Clark, Box 1191, Tulsa, Okla. '27
Mills, Coe S., 620 Prospect St., Shreveport, La. '27
Mills, R. van A., Continental Oil Co., Ponca City, Okla. '21
Milner, Charles A., Jr., 105 C St., S.W., Ardmore, Okla. '25
Milner, Henry Brewer, 92 Victoria St., Westminster, London, S.W. 1, England '31
Milstein, M., Bucareli 128, E-3, Mexico, D. F., Mexico '28
Minor, H. E., Gulf Production Co., Houston, Tex. '18
Mintrop, Ludger, Koenigshof, Hannover, Germany '31
Miser, Hugh D., U. S. Geological Survey, Washington, D.C. '23
||Mitcham, James R., 117 W. Lee, Brownwood, Tex. '28
||Mitchell, Robert B., Stanolind Oil & Gas Co., Box 788, Pampa, Tex. '29
Mix, C. A., The California Co., Drawer R, Midland, Tex. '26
Mohr, C. L., Box 811, San Angelo, Tex. '25
Moir, John, c/o J. C. Jackson, Eagle, Chambers Co., Tex. '26
Moncrief, E. C., Derby Oil Co., Wichita, Kan. '23
Monnett, V. E., 811 S. Ponca, Norman, Okla. '19
||Monroe, Watson H., U. S. Geological Survey, Washington, D.C. '31
||Monsour, T. E., Apartado 94, Tampico, Tamps., Mexico '30
||Montgomery, A. J., 801 E. Oak, Cushing, Okla. '29
Montgomery, James G., Jr., 308 Seneca St., Oil City, Pa. '26
||Montgomery, Phil C., Box 387, Chickasha, Okla. '31
Moody, Clarence L., Ohio Oil Co., Giddens-Lane Bldg., Shreveport, La. '20
Moody, Graham B., Box 1390, Station C, Los Angeles, Calif. '27
||Moody, Ray R., Gypsy Oil Co., Box 661, Tulsa, Okla. '27
||Moore, Barton W., Box 275, Kilgore, Tex. '31
Moore, John I., Holcombe-Blanton Bldg., San Angelo, Tex. '26
||Moore, Marcus H., 3150 Waits, Fort Worth, Tex. '29
Moore, Prentiss D., Holcombe-Blanton Bldg., San Angelo, Tex. '26
Moore, Raymond C., University of Kansas, Lawrence, Kan. '17
Moran, Robert B., 215 W. Seventh St., Room 434, Los Angeles, Calif. '19
Morero, Joseph E., 1305 Esperson Bldg., Houston, Tex. '23
Morgan, Ben F., Box 96, Falls City, Neb. '31
||Morgan, Cecil L., 118 W. Avenue H, San Angelo, Tex. '29
||Morgan, Charles Gill, 4608 Abbott Ave., Dallas, Tex. '31
||Morgan, D. E., Bataafsche Petr. Mij., Carel van Bylandtlaan 32, The Hague, Holland '28
Morgan, D. M., Wentz Oil Corp., Ponca City, Okla. '25
Morgan, Frank A., 774 Subway Terminal Bldg., Los Angeles, Calif. '24
Morgan, George D., Hilton Bldg., San Angelo, Tex. '22
Morgan, Henry J., Atlantic Oil Prod. Co., San Angelo, Tex. '28
Morgan, L. C., Box 677, Wichita, Kan. '30
Morley, Harold T., Stanolind Oil & Gas Co., Box 591, Tulsa, Okla. '19
Morris, A. Ferd, 1100 Dewey Ave., Bartlesville, Okla. '21
Morris, Walter W., Eagle-Picher Mining & Smelting Co., Oil & Gas Dept., Henryetta, Okla. '24
||Morrison, T. E., 310 B. Annex Humble Bldg., Houston, Tex. '27
Morse, Roy R., Shell Oil Co. of California, 429 Higgins Bldg., Los Angeles, Calif. '24
Morse, W. C., Mississippi State College, State College, Miss. '21

Mosburg, Lewis G., Stanolind Oil & Gas Co., Philcade Bldg., Tulsa, Okla........'26
Moses, Harold F., Iktisat Vekaleti, Ankara, Turkey..........................'29
Moss, Frank A., 55 West Australian Chambers, Perth, West Australia..........'29
Mossom, Stuart, 1017 Milam Bldg., San Antonio, Tex..........................'29
Moulton, Gail F., 2 Rector St., New York, N.Y...............................'23
Mower, Lowell K., Hoogeweg 6, Wassenaar, Holland............................'25
Muehlberg, M., Aarau, Switzerland...'25
||Mueller, Frederick W., 4210 W. Twenty-Ninth St., Bryan, Tex................'33
||Muir, J. Lawrence, 628 E. Maple, Enid, Okla.................................'30
Müllerried, F. K. G., 2a, del Volga 18, Mexico, D.F., Mexico................'24
Muir, John M., 706 Fort Worth Natl. Bank Bldg., Fort Worth, Tex.............'24
Mullins, William B., 1128 N. Broadway, Shawnee, Okla........................'28
Munn, M. J., Longview Hotel, Longview, Tex..................................'19
Munoz, Robert R., Petroleum Finance Corp., 42 Broadway, New York, N.Y.......'30
Munroe, Donald J., Box 566, Hattiesburg, Miss...............................'28
Munson, Herbert E., c/o Dr. D. O. Munson, Pittsburg, Kan....................'23
||Munyan, Arthur C., 267 E. High St., Lexington, Ky..........................'32
Murayama, K., No. 211, Koenji, Suginami-Ku, Tokyo, Japan....................'32
||Murchison, Eugene A., Jr., Humble Oil & Refg. Co., Box 598, Tyler, Tex.......'30
Murphy, Earle N., c/o H. B. Sherod, R.F.D., Keosauqua, Iowa.................'23
Murphy, James K., 1731 S. College, Tulsa, Okla..............................'28
Murray, A. N., Dept. of Geology, University of Tulsa, Tulsa, Okla...........'30
Myers, Desaix B., Union Oil Co. of California, Union Oil Bldg., Los Angeles, Calif...'25
Myers, John C., 3707 Graustark St., Houston, Tex............................'22
Myers, Julian Q, 1118 S. Texas Bank & Trust Co., San Antonio, Tex...........'23
||Mygdal, Karl A., Standard Oil Co. of Venezuela, Caripito, Venezuela, via Trinidad, B.W.I..................'30
Mylius, L. A., 1710 N. Walnut, Hutchinson, Kan..............................'21

Naramore, Chester, c/o Crandall & Osmond, 17 Battery Pl., New York, N.Y.....'21
Nash, Howard F., Apartado 234, Maracaibo, Venezuela, S. A...................'20
Neal, Earl S., Apartado 172, Maracaibo, Venezuela, S. A.....................'30
Nedom, Henry A., 2516 N. Main St., Tulsa, Okla..............................'29
||Neel, Merrill A., Tecumseh, Okla..'27
||Nelson, Floyd A., Geological Dept., Shell Petr. Corp., St. Louis, Mo.........'30
||Nelson, James C., 1632 Milam Bldg., San Antonio, Tex.........................'29
Nelson, Jean O., 1919 W. Magnolia St., San Antonio, Tex.....................'22
Nelson, Richard N., 1102 Standard Oil Bldg., San Francisco, Calif...........'26
Nelson, Walter S., Box 348, Shelby, Mont....................................'20
Netick, Joe, Orinoco Oil Co., Apartado 168, Maracaibo, Venezuela, S. A......'29
||Nettleton, L. L., Gulf Research Lab., 327 Craft Ave., Pittsburgh, Pa........'30
Neumann, Fred R., 6261 Hyacinth St., Chicago, Ill...........................'31
Neumann, L. Murray, Carter Oil Co., Box 801, Tulsa, Okla....................'19
Nevin, Charles M., 203 E. Upland St., Ithaca, N.Y...........................'22
Newby, Jerry B., 1816 N.W. Twenty-Third St., Oklahoma City, Okla............'17
Newcombe, Robert J. B., Geological Survey Div., Lansing, Mich...............'29
Newman, Thomas F., Geological Dept., Skelly Oil Co., Tulsa, Okla............'25
Nicholls, William M., 2102 Berkeley Drive, Wichita Falls, Tex...............'27
Nichols, C. R., Box 2880, Dallas, Tex.......................................'20
||Nicola, Oliver P., Jr., 2012 W. Cherokee St., Enid, Okla.....................'28
Nightingale, W. T., Mountain Fuel Supply Co., Rock Springs, Wyo.............'24
Nisbet, John M., 703 Empire Bldg., Bartlesville, Okla.......................'18
Noble, Arthur H., Sarawak Oilfields Ltd., Miri, Sarawak, via Singapore......'24
Noble, Earl B., Union Oil Co. of California, 1115 Union Oil Bldg., Los Angeles, Calif. '24
Noble, Gilbert W., 43 Limaean St., Cambridge, Mass..........................'26
Noble, Homer A., 1651 Colquitt, Houston, Tex................................'20
Nolan, Philip E., Venezuelan Gulf Oil Co., Maracaibo, Venezuela, S. A.......'25
Nolte, William J., Stanolind Oil & Gas Co., Medical Arts Bldg., Fort Worth, Tex. '23
Nomland, J. O., Standard Oil Bldg., San Francisco, Calif....................'28
Nordman, O. E., 829 E. Fifteenth St., Ada, Okla.............................'23
North, Lloyd, 2041 Brandard Ave., Houston, Tex..............................'22
Norton, George H., Atlantic Oil Prod. Co., 906 Central Bldg., Wichita, Kan..'21
||Norton, Richard D., The Texas Co., Box 1737, Shreveport, La..................'28

Norville, Glen S., Box 1267, Ponca City, Okla. '29
Notestein, Frank B., The Texas Co., Houston, Tex. '20
Nowels, Kenneth B., Forest Oil Corp., Bradford, Pa. '23
Nowlan, Harry H., 601 Milam Bldg., San Antonio, Tex. '21
Nufer, D. C., Box 801, Tulsa, Okla. '30
Nuttall, W. L. F., Longfield, Madingley Rd., Cambridge, England '24
‖Nye, S. Spencer, Route 1, Box 67 E, Brownsville, Tex. '27

‖O'Bannon, P. H., Thompsons, Tex. '30
Obering, Ernest A., Box 868, San Angelo, Tex. '24
Oborne, Harry W., 1328 N. Tejon Ave., Colorado Springs, Colo. '23
‖O'Brien, Shamus, Florence, Kan. '23
Officer, Herbert G., 1755 S. St. Louis St., Tulsa, Okla. '22
‖Ogier, E. H., 2333 Foster Ave., Ventura, Calif. '31
Ohern, D. W., 515 W. Fourteenth St., Oklahoma City, Okla. '18
‖O'Keeffe, Hugh W., Phillips Petr. Co., Box 152, Shawnee, Okla. '30
Olcott, David Perry, Box 887, Lake Charles, La. '33
Oldham, Albert E., Arkansas Nat. Gas Corp., Shreveport, La. '25
Oliphant, A. G., 2114 S. Norfolk, Tulsa, Okla. '27
Olson, Walter S., Colombian Petr. Co., Apartado 100, Cucuta, Colombia, S. A. '27
Olsson, Axel A., 48 Woodside Ave., Gloversville, N.Y. '20
*Orcutt, W. W., Union Oil Co., Union Oil Bldg., Los Angeles, Calif. '26
Ordoñez, Ezequiel, Abraham Gonzalez 79, Mexico City, Mexico '24
‖Orr, Everett, Marlow, Okla. '33
Orr, Milo M., Box 191, Laredo, Tex. '20
Orynski, Leonard W., The California Co., 17th Floor Tower Petroleum Bldg., Dallas, Tex. '23
Osborne, Clarence B., 402 Security Bldg., Los Angeles, Calif. '21
‖Osborne, Paul F., 737 Clayton St., Denver, Colo. '30
Osborne, Robert R., Alamo Natl. Bldg., San Antonio, Tex. '23
‖Osorio, Gustave A., Apartado 153, Barranquilla, Colombia, S. A. '31
Ott, Emil, Box 578, San Angelo, Tex. '24
Owen, Edgar W., 1716 Milam Bldg., San Antonio, Tex. '19
‖Owen, Kenneth Dale, 1616 S. Main St., Houston, Tex. '27
Owens, Allen L., Trinidad Oilfields Operating Co. Ltd., Box 18, San Fernando, Trinidad, B.W.I. '20
Owens, Frith C., Box 548, Laredo, Tex. '26

Pack, R. W., Drawer 790, Beaumont, Tex. '18
Packard, Sidney A., Geological Dept., Arkansas Nat. Gas Co., Shreveport, La. '21
Page, James H., Box 871, Tulsa, Okla. '25
‖Palmer, Katherine V. W., Dept. of Geology, Cornell University, Ithaca, N.Y. '28
Palmer, Robert H., Hotel Andino, Habana, Cuba '23
Parker, Ben H., 1007 Twelfth St., Golden, Colo. '28
Parker, Everett C., 319 Carancahua, Corpus Christi, Tex. '17
Parker, Robert L., Box 493, Rolla, Mo. '27
Parks, Ernest K., Bin XX, Taft, Calif. '25
‖Parris, Frank G., 1516 Highland Drive, Charleston, W.Va. '29
Parrish, Gaston H., 1515 Chaparral St., Corpus Christi, Tex. '25
‖Parsons, Claude P., Halliburton Cementing Co., Duncan, Okla. '27
‖Paschal, Elisha A., 1012 Tradesmen's Natl. Bank Bldg., Oklahoma City, Okla. '22
Patrick, Walden W., Box 1208, Midland, Tex. '21
Patterson, J. M., 1211 N. Eighteenth St., Apt. 104, Kansas City, Kan. '25
‖Patterson, Luther Edwin, Jr., 930 W. Fourteenth St., Oklahoma City, Okla. '30
Patton, Leroy T., Texas Technological College, Lubbock, Tex. '24
Paxson, Roland B., 1857 Lexington St., Houston, Tex. '26
‖Payne, Willard M., Box 867, Clewiston, Fla. '30
Peabody, Harlan W., Box 381, Tulsa, Okla. '19
Pellekaan, W. Van Holst, Shell Petr. Corp., Shell Bldg., St. Louis, Mo. '21
Pellissier, Andre, Pechelbronn S. A. E. M., Bibliotheque Technique à Merkwiller-Pechelbronn, Strasbourg, France '25
Pemberton, J. R., 525 N. Palm Drive, Beverly Hills, Calif. '17

Penny, Frederick W., Phoenix Oil & Transport Co., Casuta Postala No. 1, Ploestia, Roumania....'24
Pepperberg, Leon J., First Natl. Bank Bldg., Dallas, Tex....'19
Perini, Vincent C., Jr., Box 886, San Angelo, Tex....'23
Perkins, Joseph M., Box 1105, Eastland, Tex....'19
Perkinson, Floyd, R.F.D. 1, Purcell, Okla....'31
Perrine, Irving, 1619-21 Petroleum Bldg., Oklahoma City, Okla....'17
Perry, Donald C., Lemoore, Kings Co., Calif....'32
Peterson, Clarence J., Texoma Nat. Gas Co., Fourth Floor Rule Bldg., Amarillo, Tex....'19
Petrascheck, Wilhelm, Geological Museum, Mining Academy, Leoben, Austria....'28
Petsch, Arthur H., Box 318, Laredo, Tex....'20
Pettigrew, Virgil, Humble Oil & Refg. Co., Box 299, Wichita Falls, Tex....'25
Petty, Dabney E., 10 Tenth St., San Antonio, Tex....'20
Petty, O. S., 10 Tenth St., San Antonio, Tex....'31
Petty, T. F., Box 400, Cisco, Tex....'29
‖Pfaankuche, Kathleen Tarver, 3240 James St., Fort Worth, Tex....'29
Philbrick, E. P., Magnolia Petr. Co., Box 1862, Wichita, Kan....'23
‖Phillippi, Paul Miller, Olean Petr. Co., Box 522, Olean, N.Y....'30
‖Phipps, J. B., Jr., Gulf Production Co., Borger, Tex....'33
Pike, Ruthven W., Standard Oil Co. S. A. Argentina, General Ballivian FCCNA, Provincia de Salta, Argentina, S. A....'29
‖Pilcher, Ben L., Jr., The Texas Co., Houston, Tex....'30
‖Pinkley, George R., Creole Petr. Corp., Caripito, Venezuela, S. A....'29
Pirtle, George W., Box 940, Tyler, Tex....'27
Pittman, C. V. A., 67 Southwest Fourteenth St., Miami, Fla....'32
‖Plaster, William M., Alpena Pass, Ark....'29
Plummer, F. B., University of Texas, Bureau of Economic Geology, Austin, Tex..'19
Pogue, Joseph E., 43 Fifth Ave., New York, N.Y....'24
‖Poland, Joseph F., Encena Ave., Box 345, Menlo Park, Calif....'31
Ponton, G. M., Florida State Geological Survey, Tallahassee, Fla....'29
Porch, Edwin L., Jr., Box 573, San Antonio, Tex....'20
‖Porter, John L., 181 Claremont, Long Beach, Calif....'32
Porter, William W., 8315 Beverly Blvd., Los Angeles, Calif....'27
Posey, Ellen, The Empire Companies, Bartlesville, Okla....'33
‖Pospisil, Frank J., Lago Petr. Corp., Apartado 172, Maracaibo, Venezuela, S. A....'29
‖Postley, Olive C., The Calverton, Washington, D.C....'26
Potter, Grover C., 740 Estes Ave., San Antonio, Tex....'22
Potter, Nelson B., c/o J. R. Steele, DeKalb, Mo....'26
Poulin, John A., Sinclair Exploration Co., 45 Nassau St., New York, N.Y....'32
Poulsen, Frank E., 3203 W. Oneal St., Greenville, Tex....'25
Powell, Ralph S., The Texas Co., Wichita Falls, Tex....'27
Power, Harry H., 1543 E. Nineteenth St., Tulsa, Okla....'28
Powers, Delmer L., 228 Avenue F, Billings, Mont....'29
Pratt, Ernest S., Box 1400, Wichita, Kan....'22
Pratt, Wallace E., Humble Oil & Refg. Co., Houston, Tex....'18
Pressler, Edward D., Humble Oil & Refg. Co., Uvalde, Tex....'31
Preston, John Basil, Glasgow, Ky....'28
Prettyman, T. M., 1901 W. T. Waggoner Bldg., Fort Worth, Tex....'24
Price, Sylvan S., 1502 Philtower Bldg., Tulsa, Okla....'17
Price, W. Armstrong, Box 112, Corpus Christi, Tex....'25
Prommel, Harald W. C., 731 S. Downing St., Denver, Colo....'22
Prout, F. S., Box 417, Tyler, Tex....'17
Purzer, Joseph, Geological Dept., Phillips Petr. Co., Bartlesville, Okla....'26
‖Putnam, George D., 1108 Brown Bldg., Wichita, Kan....'27
‖Pyle, Howard C., 3932 Roderick Rd., Los Angeles, Calif....'29
Pyle, James R., Box 416, Owensboro, Ky....'20

Quiett, Roy C., Indian Territory Illuminating Oil Co., Seminole, Okla....'22

Radcliffe, D. H., 707 S. Hill St., Los Angeles, Calif....'20
Rae, Colin C., Skelly Oil Co., Box 2087, Tulsa, Okla....'19
Ragsdale, Thomas M., Magnolia Petr. Co., Box 971, Oklahoma City, Okla....'31

Ralston, Wallace, Box 807, Tyler, Tex. '23
‖Rankin, Charles H., Jr., Geological Dept., Room 1042, Continental Oil Bldg., Denver, Colo. '31
Rankin, Charles L., Humble Oil & Refg. Co., 818 Hodges Bldg., Lake Charles, La. '27
‖Rankin, Horace Ellis, Cia. Mex. de Petr. "El. Aquila," S.A., Apartado 150, Tampico, Mexico '31
Rankin, Wilbur D., 1325 Opechee Way, Glendale, Calif. '27
‖Ransone, William Robert, 1311 Republic Bank Bldg., Dallas, Tex. '33
Rau, Harold L., Carter Oil Co., Seminole, Okla. '25
Rau, William M., 929 American, Long Beach, Calif. '28
Rauch, Wayne C., Superior Oil Co., 504 Esperson Bldg., Houston, Tex. '27
‖Reagan, Paul H., Nevada City, Calif. '28
Redfield, John S., Shell Petr. Corp., Box 1191, Tulsa, Okla. '27
Redmon, Harold E., National Refg. Co., 206 Mid-Continent Bldg., El Dorado, Kan. '30
‖Reed, Edwin M., 1729 S. Evanston, Tulsa, Okla. '27
Reed, Eugene C., 1316 S. Twenty-Fourth St., Lincoln, Neb. '28
Reed, Lyman C., Lago Petr. Corp., Apartado 172, Maracaibo, Venezuela, S. A. '22
Reed, Ralph D., 1110 Glendon Way, S. Pasadena, Calif. '20
‖Reed, Warren B., 731 Royal St., New Orleans, La. '22
Reese, Donald M., Box 908, Tyler, Tex. '30
Reese, Richard G., 631 S. Greenleaf Ave., Whittier, Calif. '27
Reeside, John B., Jr., Box 175, Hyattsville, Md. '26
Reeves, John R., Penn-York Nat. Gas Corp., Coudersport, Pa. '24
‖Regan, John H., Anthony Arms Apts., McAllen, Tex. '30
Reger, David B., Box 816, Morgantown, W.Va. '19
Reisher, Paul H., Box 661, Tulsa, Okla. '21
Reiter, Wilhelm A., Box 856, Mexia, Tex. '22
Remington, Arthur E., Pure Oil Co., 1140 Subway Terminal Bldg., Los Angeles, Calif. '25
Renaud, Charles L., 1901 W. T. Waggoner Bldg., Fort Worth, Tex. '23
Renick, B. Coleman, 1704 Alamo Natl. Bldg., San Antonio, Tex. '25
Rennie, Waldo E., 1520 Steele St., Denver, Colo. '25
Requa, Lawrence K., Mills Bldg., San Francisco, Calif. '28
Rettger, Robert E., Sun Oil Co., Milam Bldg., San Antonio, Tex. '25
Reynolds, Roy A., 2301 Fort Worth Natl. Bank Bldg., Fort Worth, Tex. '19
Rhine, Elton, Box 956, Houston, Tex. '23
Rhoades, Ralph O., Gulf Cos., Gulf Bldg., Pittsburgh, Pa. '24
Rhoades, Roy S., 1311 Edwards & Wildey Bldg., Los Angeles, Calif. '23
‖Rhodes, Edward J., 45 Thornton St., Wollaston, Mass. '31
Ribble, John M., 1523 N.W. Thirty-Sixth St., Oklahoma City, Okla. '31
‖Rice, Elmer M., Box 22 J, Van, Tex. '27
Rich, John L., Dept. of Geology, University of Cincinnati, Cincinnati, Ohio '19
Richards, J. T., Gypsy Oil Co., 901 Petroleum Bldg., Oklahoma City, Okla. '24
Richards, Ralph W., 2717 Connecticut Ave., N.W., Washington, D.C. '19
Richards, Raymond, 17 Battery Pl., New York, N.Y. '25
‖Richardson, H. T., Box 96, Cuero, Tex. '30
Richmond, Wallace E., Jr., 22 School St., Andover, Mass. '27
Rider, Charles R., Apartado 223, Maracaibo, Venezuela, S. A. '20
Ridgeway, Bertrand S., 206 S. Fourteenth St., Independence, Kan. '21
Ries, Heinrich, Department of Geology, Cornell University, Ithaca, N.Y. '26
‖Ries, Minette, Phillips Petr. Co., Amarillo, Tex. '30
Rife, Byron, 1017 Milam Bldg., San Antonio, Tex. '23
‖Riggs, Calvin H., Box 34, Muskegon, Mich. '32
Riggs, Robert J., Drawer L, Bartlesville, Okla. '17
Ring, Dewitt T., Ohio Fuel Gas Co., 99 N. Front St., Columbus, Ohio '20
Riter, Samuel W., Box 661, Tulsa, Okla. '26
Ritter, Ernest A., Chief Geologist, Cia. Mex. de Petr. "El Aguila," S. A., Tampico, Mexico '30
Rixleben, Bruno, Box 904, Holdenville, Okla. '27
Roark, Edward L., Winona Oil Co., 1020 Kennedy Bldg., Tulsa, Okla. '22
Roark, Louis, 2652 S. Trenton, Tulsa, Okla. '19
Roark, R. B., Shell Petr. Corp., Box 1191, Tulsa, Okla. '21

Roberts, Dwight C., 2000 W. Twelfth St., Los Angeles, Calif. .... '25
Roberts, Louis C., Jr., Stanolind Oil & Gas Co., 2912 Gulf Bldg., Houston, Tex... '25
Roberts, Morgan E., Box 637, Odessa, Tex. .... '20
Robertson, Glenn D., Shell Petr. Corp., Box 7, Buffalo, Tex. .... '26
Robinson, B. F., 709 E. Thirteenth St., Cameron, Tex. .... '21
Robinson, Cecil D., 716 S. Arkansas Ave., Russellville, Ark. .... '28
Robinson, Ernest Guy, Shell Petr. Corp., Drawer 15, St. Louis, Mo. .... '22
Robinson, Heath M., 815 Tower Petroleum Bldg., Dallas, Tex. .... '22
Robinson, J. French, 545 William Penn Way, Pittsburgh, Pa. .... '20
Robinson, W. I., Department of Geology, Texas Technological College, Lubbock, Tex. .... '22
Rogatz, Henry, 124 E. Eighty-Fourth St., New York, N.Y. .... '25
Rohwer, F. W., 745 Highland, Boulder, Colo. .... '24
Rollin, George S., 2518 E. Twenty-Seventh St., Tulsa, Okla. .... '21
‖Rolshausen, F. W., 308 B. Annex Humble Bldg., Houston, Tex. .... '28
Romine, Thomas B., Box 2110, Fort Worth, Tex. .... '23
Roop, Charles W., 3551 E. Douglas, Wichita, Kan. .... '22
Rosaire, Carol G., 2110 Esperson Bldg., Houston, Tex. .... '31
Rosaire, E. E., 2210 Esperson Bldg., Houston, Tex. .... '31
Roschen, Ernest C. H., Cherry Hill Lane, Reisterstown, Md. .... '29
Rose, Harrison W., Sun Oil Co., Beaumont, Tex. .... '30
Rosenthal, Bernard, Box 126, Mexico, Mo. .... '28
‖Ross, Charles M., Geophysical Research Corp., Drawer 2040, Tulsa, Okla. .... '29
Ross, Clarence S., U. S. Geological Survey, Washington, D.C. .... '19
Ross, John C., 1923 S. Wheeling, Tulsa, Okla. .... '21
Roth, Robert, 1203 S. Quaker, Tulsa, Okla. .... '29
Rothrock, E. P., 311 Canby St., Vermillion, S. Dakota. .... '19
Rothrock, Howard E., 1801 W. Easton Court, Tulsa, Okla. .... '21
Roundy, P. V., U. S. Geological Survey, Washington, D.C. .... '19
Rousselot, Norman A., 970 Subway Terminal Bldg., 417 S. Hill St., Los Angeles, Calif. .... '27
Row, Charles H., 1029 Milam Bldg., San Antonio, Tex. .... '19
Rowland, W. Boyd, Union Sulphur Co., Sulphur, La. .... '26
Ruby, Glen M., 1550 Golf Club Drive, Glendale, Calif. .... '22
Ruedemann, Paul, Wattmanngasse 39, Wien, XIII, Austria .... '21
‖Rupnik, John J., Geophysical Div., The Texas Co., Houston, Tex. .... '33
Rusk, Willard W., 2207 Hayden St., Amarillo, Tex. .... '26
Russ, Leon F., 3606 Princeton Ave., Dallas, Tex. .... '19
Russell, C. A., 18th Floor Petroleum Bldg., Houston, Tex. .... '29
‖Russell, J. J., Jr., Texas Pacific Coal & Oil Co., Midland, Tex. .... '29
Russell, Philip G., Box 635, Eastland, Tex. .... '21
Russell, William L., 430 Temple St., New Haven, Conn. .... '24
Russom, Vaughn W., Box 146, Oakwood, Tex. .... '21
Rutledge, R. B., Box 1650, Tulsa, Okla. .... '26
Ryan, Reginald G., 1620 Kirby Bldg., Dallas, Tex. .... '23
Ryan, Russell F., 512 McGowen Ave., Houston, Tex. .... '26
Ryniker, Charles, Box 661, Tulsa, Okla. .... '25

Sackett, H. F., 503 Kennedy Bldg., Tulsa, Okla. .... '27
Salvatori, Henry, Western Geophysical Co., 950 S. Flower St., Los Angeles, Calif. .. '30
Sanders, C. W., Jr., Box 1651, Amarillo, Tex. .... '27
Sanderson, James O. G., Box 134, Turner Valley, Alta., Canada .... '28
Sandidge, John R., 1704 Alamo Natl. Bldg., San Antonio, Tex. .... '29
Sands, J. M., Phillips Petr. Co., Bartlesville, Okla. .... '17
‖Sanford, D. H., 2432 E. First St., Duluth, Minn. .... '30
‖Sargent, E. C., Bureau of Economic Geology, Austin, Tex. .... '30
Sasse, Jerome B., Shell Petr. Corp., Box 2099, Houston, Tex. .... '29
Saville, Wilson G., 1406-10 Shell Bldg., Houston, Tex. .... '29
Sawtelle, George, Kirby Petr. Co., Houston, Tex. .... '22
Sawyer, Roger W., 1616 S. Seventeenth St., Chickasha, Okla. .... '20
‖Sax, Henri, Ard. Pauwstr. 19, den Haag, Holland .... '26
Say, Stanley R., Nix Hospital, Room 2106, San Antonio, Tex. .... '26
‖Sayre, J. E., 1921 Broadway, Shawnee, Okla. .... '26

||Schaeffer, Hugh C., 3416 N.W. Twentieth St., Oklahoma City, Okla............'25
||Schenck, Francis R., 832 Bowie, Amarillo, Tex............................'32
Schider, Rodolphe, Cia. Mexicana de Petr. "El Aguila," Apartado 150, Tampico, Mexico..'28
Schilling, Karl H., 308 Bearinger Bldg., Saginaw, Mich.......................'23
Schlaich, E. P., Caribbean Petr. Co., Maracaibo, Venezuela, S. A..............'34
Schlosser, Paul A., Box 816, San Angelo, Tex................................'23
Schlumberger, Conrad, Prospection Electrique, 30 Rue Fabert, Paris VIIe, France '31
Schmidt, Karl A., Tidal Oil Co., W. T. Waggoner Bldg., Fort Worth, Tex........'25
||Schmotzer, J. W., 124 E. Jordan St., Shreveport, La.........................'31
Schneider, G. W., Box 1737, Shreveport, La..................................'25
Schnurr, Cornelius, 2922 Gulf Bldg., Houston, Tex...........................'22
Schoeneck, Philip S., Atlantic Oil Prod. Co., Box 642, Laredo, Tex.............'21
Scholl, Louis A., Jr., 2232 Stanmore Drive, Houston, Tex.....................'19
Schoolfield, R. F., 2121 Alamo Natl. Bldg., San Antonio, Tex..................'21
Schramm, E. F., Morrill Hall, University of Nebraska, Lincoln, Neb.............'19
Schouten, Franklin H., 115 E. Berta St., Tyler Tex..........................'26
Schuchert, Charles, Yale University, New Haven, Conn........................'19
Schumacher, J. P., 1028 Shell Bldg., Houston, Tex...........................'24
Schürmann, H. M. E., van voorschotenlaan 2, The Hague, Holland...............'31
Schwabrow, John R., U. S. Geological Survey, Federal Bldg., Casper, Wyo........'27
Schwarz, Melbert E., 1304½ Kings Highway, Dallas, Tex........................'25
||Schweer, Henry, Portland Cement Association, 142 First Natl. Bank Bldg., Oklahoma City, Okla..'28
Schwennesen, Alvin T., 1011 Sterling Bldg., Houston, Tex.....................'25
Sclater, Kenneth C., The Petroleum Engineer, Tower Petroleum Bldg., Dallas, Tex...'26
Scott, Gayle, Texas Christian University, Fort Worth, Tex.....................'21
||Scott, Horace L., 610-12 Ellis Singleton Bldg., Wichita, Kan.................'28
Scott, H. M., 533 Beacon Life Bldg., Tulsa, Okla.............................'21
||Scott, Vernon C., The Texas Co., Box 127, Perry, Okla........................'31
Scruggs, M. Dale, Continental Oil Co., Box 1267, Ponca City, Okla.............'26
Scudder, Ernest W., Box 2097, Denver, Colo..................................'17
Sealey, Fred C., The Texas Co., Box 2332, Houston, Tex.......................'20
||Searight, Walter V., 24 N. Yale St., Vermillion, S. Dakota....................'32
Sears, Julian D., 209 E. Underwood St., Chevy Chase, Md......................'24
Seashore, Paul T., 1112 Whitney Bldg., New Orleans, La.......................'27
||Secor, Dana M., Houston Oil Co., Petroleum Bldg., Houston, Tex...............'28
||Seevers, Harris N., 1713 Third St., Corpus Christi, Tex......................'27
||Seifert, Wilbur H., United Nat. Gas Co., R.F.D., Hallton, Pa.................'32
Seitz, J. R., 532 Waggoner Bldg., Wichita Falls, Tex.........................'24
||Self, Selden R., Box 989, San Angelo, Tex...................................'29
Selig, A. L., 2432 Shirley Ave., Fort Worth, Tex.............................'23
Sellards, E. H., University of Texas, Bureau of Economic Geology, Austin, Tex...'19
Semmes, Douglas R., 2001 Milam Bldg., San Antonio, Tex.......................'19
Severson, George A., Geological Dept., Calle Chile 778, Buenos Aires, Argentina, S. A...'26
Seymour, D. Bruce, Continental Oil Co., 417 S. Hill St., Los Angeles, Calif......'28
Shakely, Ed., Shell Petr. Corp., Box 713, McPherson, Kan......................'25
||Shamblin, William E., Box 296, Holdenville, Okla.............................'27
Shaub, Benjamin M., 16 Paradise Rd., Northampton, Mass.......................'32
Shaw, E. Wesley, Iraq Petr. Co. Ltd., City Gate House, Finsbury Square, London, E.C. 2, England...'18
Shaw, Everett S., 3131 Zenobia St., Denver, Colo.............................'22
||Shay, D. C., 2626 Haste St., Berkeley, Calif................................'30
Shayes, Fred P., United Production Corp., Beeville, Tex......................'23
Shea, E. F., 2207 E. Twentieth St., Tulsa, Okla..............................'21
Shearer, Harold K., Box 532, Shreveport, La..................................'20
Sheldon, Israel R., 1623 Smith-Young Tower, San Antonio, Tex..................'21
Shelton, George H., 1704 Milam Bldg., San Antonio, Tex.......................'27
Shepard, Edward M., 1403 Benton Ave., Springfield, Mo........................'19
Sheppard, George, Casilla 410, Guayaquil, Ecuador, S. A.......................'27
Sherman, Richard W., 714 W. Tenth St., Room 918, Los Angeles, Calif...........'28

Sherman, Roger H., Standard Oil Co. of Venezuela, Caripito, Venezuela (via Trinidad), S. A. ....'32
Sherrill, Richard E., Dept. of Geology, University of Pittsburgh, Pittsburgh, Pa. ....'27
Sherry, William J., 841 Kennedy Bldg., Tulsa, Okla. ....'27
Shiarella, Nicholas W., 619 Frederica St., Owensboro, Ky. ....'22
Shoenfelt, C. E., 401 Continental Oil Bldg., Denver, Colo. ....'28
Shuler, Ellis W., Southern Methodist University, Dallas, Tex. ....'19
Shutt, Roscoe E., Shell Petr. Corp., Box 1191, Tulsa, Okla. ....'23
Sickler, Jack M., 734 Pacific Mutual Bldg., Los Angeles, Calif. ....'19
Sidwell, Carroll V., Box 902, Seminole, Okla. ....'22
Sidwell, Raymond, Dept. of Geology, Texas Technological College, Lubbock, Tex. ..'28
Siegfus, Stanley S., K. N. D. A., Box 120, Coalinga, Calif. ....'28
||Simmons, Kenneth A., 438 Donaldson, San Antonio, Tex. ....'29
Simmons, Rouse, 418 Bartlett Bldg., Los Angeles, Calif. ....'26
||Simonton, Owen W., 886 E. Broad St., Columbus, Ohio ....'31
||Simpson, Richard W., Jr., Ada, Okla. ....'30
||Sinclair, W. B., Amerada Petr. Corp., Wichita, Kan. ....'34
Singewald, Joseph T., Jr., 17 W. Twenty-Ninth St., Baltimore, Md. ....'21
Singewald, Quentin D., University of Rochester, Rochester, N.Y. ....'27
Sisler, James D., Box 879, Morgantown, W.Va. ....'31
Skirvin, Orren W., Skirvin Hotel, Oklahoma City, Okla. ....'21
Slipper, S. E., 215 Sixth Ave. W., Calgary, Alta., Canada ....'23
Small, Walt M., Cooperstown, Pa. ....'17
Smalley, Claire F., 722 N. Eighth St., Duncan, Okla. ....'31
||Smedley, Harold O., 901 H St., Lincoln, Neb. ....'28
Smiley, H. F., 222 Hamilton Bldg., Wichita Falls, Tex. ....'23
Smith, A. E., Shell Petr. Corp., Box 2099, Houston, Tex. ....'31
||Smith, Colin Hubbard, 2082 S. Harvard Blvd., Los Angeles, Calif. ....'31
||Smith, Erwin W., 2202 Esperson Bldg., Houston, Tex. ....'24
||Smith, Floyd C., 501 N. Creek, Holdenville, Okla. ....'30
Smith, George J., 550 Bowdoin St., Palo Alto, Calif. ....'27
*Smith, George Otis, 2137 Bancroft Pl., Washington, D.C. ....'26
||Smith, Gerald N., 120 S.E. Forty-Third St., Oklahoma City, Okla. ....'27
||Smith, Julian W., Box 1116, Enid, Okla. ....'30
||Smith, Lee C., Sun Oil Co., Box 2880, Dallas, Tex. ....'31
Smith, Lloyd B., 2617 Dillard St., Shreveport, La. ....'20
||Smith, Luther B., Jr., Box 345, Cuero, Tex. ....'30
Smith, Merritt B., 951 Lincoln Ave., Palo Alto, Calif. ....'22
Smith, Richard A., Geological Survey Div., State Office Bldg., Lansing, Mich. ....'22
Smith, Wayne M., 2900 Parkway, Bakersfield, Calif. ....'28
Snider, George W., 228 Belvidere Drive, San Antonio, Tex. ....'24
Snider, L. B., 319 Parland Pl., San Antonio, Tex. ....'19
Snider, L. C., Henry L. Doherty & Co., 60 Wall St., New York, N.Y. ....'18
Snow, D. R., Box 2039, Tulsa, Okla. ....'20
Snyder, John Y., 1211 City Bank Bldg., Shreveport, La. ....'20
Solliday, A. L., Box 591, Tulsa, Okla. ....'22
Somers, Ransom E., The Gulf Cos., Frick Bildg. Annex, Pittsburgh, Pa. ....'19
Soper, E. K., 845 Muirfield Rd., Los Angeles, Calif. ....'25
Soper, Ralph H., Standard Oil Co. of Indiana, 910 S. Michigan Ave., Chicago, Ill. ..'31
Sorenson, I. L., Humble Oil & Refg. Co., Gladewater, Tex. ....'31
Sparks, Dale Darrell, 4151 Normal Ave., Hollywood, Calif. ....'27
||Spaulding, Ralph V., Drawer 2040, Tulsa, Okla. ....'29
Spears, Walter H., United Gas System, Box 1760, Houston, Tex. ....'28
||Speed, C. D., Jr., 1514 Magnolia Bldg., Dallas, Tex. ....'30
||Spencer, Lawrence P., Tri-State Gas & Elec. Corp., Elmira, N.Y. ....'30
||Spencer, Maria, 502 Oklahoma Savings Bldg., Oklahoma City, Okla. ....'30
Spice, William H., Jr., Alamo Natl. Bldg., Room 2117, San Antonio, Tex. ....'24
Spieker, Edmund M., Dept. of Geology, Ohio State University, Columbus, Ohio. .'23
||Splane, Howard Scott, Box 1379, Tulsa, Okla. ....'25
Spofford, Howard N., 3427 Beverly Pl., Shreveport, La. ....'24
Spooner, W. C., Box 1195, Shreveport, La. ....'18
Spoor, Harry C., Jr., United Production Corp., Box 1760 Houston, Tex. ....'28
||Sprague, Robert D., Box 1990, Fort Worth, Tex. ....'33

Sprague, William B., 1701 Alamo Natl. Bldg., San Antonio, Tex. '24
||Spratt, J. G., Dept of Lands and Mines, New Telephone Bldg., Calgary, Alta., Canada '30
Sprowls, Harlan A., 423 La Plante Bldg., Vincennes, Ind. '27
Stacy, Dean M., 2821 First Natl. Bank Bldg., Oklahoma City, Okla. '17
Staehelin, Peter Karl, C.M.P. El Aguila S. A., Apartado 86, Puerto Mexico, Ver., Mexico '30
Stafford, Clare J., Darby Petr. Corp., 802 Ellis-Singleton Bldg., Wichita, Kan. '27
Stainbrook, Merrill A., Texas Technological College, Lubbock, Tex. '29
Stalder, Walter, 925 Crocker Bldg., San Francisco, Calif. '22
Staley, C. G., Proration Office, Hobbs, N. Mex. '30
||Stamey, Roderick A., Mt. Belvieu, Tex. '31
Stathers, Silas C., 65 S. Florida St., Buckhannon, W.Va. '19
Stauffer, Clinton R., 107 Pillsbury Hall, University of Minnesota, Minneapolis, Minn. '19
Stauft, J. Lauer, International Petr. Co., Negritos, Peru, S. A. '26
St. Clair, Stuart, 420 Lexington Ave., New York, N.Y. '19
St. Germain, R. J., 710 Sterling Bldg., Houston, Tex. '26
Stearn, Noel H., 2101 Missouri Pacific Bldg., St. Louis, Mo. '29
Stebinger, Eugene, Standard Oil Co. of New Jersey, 30 Rockefeller Plaza, New York, N.Y. '20
||Steel, Robert J., Apt. A, 1302 N. Broadway, Santa Ana, Calif. (Mail returned) '31
Steig, Maynard, 1118 South Texas Bank Bldg., San Antonio, Tex. '28
Stein, Ira H., 2522 Gulf Bldg., Houston, Tex. '23
Steinberger, Clark R., 3337 Wichita, Houston, Tex. '28
Steineke, Max, Route 1, Box 391, Los Altos, Calif. '28
Steinmayer, R. A., Tulane University, New Orleans, La. '20
Steiny, Homer J., Associated Oil Co., 736 Pacific Electric Bldg., Los Angeles, Calif. '25
||Stephens, Clayton W., Box 217, Venice, Calif. '29
Stephenson, Cuthbert, Box 923, Pawhuska, Okla. '22
Stephenson, Eugene A., Missouri School of Mines, Rolla, Mo. '19
Stephenson, Lloyd W., 3421 Lowell St., Washington, D. C. '25
Sterrett, Douglas B., Box 150, Kamloops, B. C., Canada '25
Steubing, W. C., 513 Natl. Bank of Commerce Bldg., San Antonio, Tex. '20
Stevens, George D., Box 2252, Houston, Tex. '30
Stewart, Charles A., 1546 W. Magnolia, San Antonio, Tex. '27
Stewart, Hugh A., 612 Gaylord St., Denver, Colo. '23
Stewart, Irvine E., 548 Subway Terminal Bldg., Los Angeles, Calif. '18
Stewart, R. E., Box 745, Ventura, Calif. '28
||Stewart, Robert J. G., Box 654, Rockdale, Tex. '28
Stiles, Edmund B., Box 503, Palestine, Tex. '20
Stiles, Elisabeth, 705 E. Nineteenth St., Houston, Tex. '27
Still, J. T., 3 Oak Court, Houston, Tex. '31
Stille, Hans, Geological Institute, University of Berlin, Berlin, Germany '31
Stiller, Ernest A., Box 1734, Shreveport, La. '27
Stipek, Raymond J., 1271 Fillmore St., Topeka, Kan. '29
Stipp, Thomas F., 1145 Webster St., Palo Alto, Calif. '23
||Stirtz, W. Melvin, Box 1251, Bartlesville, Okla. '28
Stockton, Frank R., Standard Oil Co. of California, Box 87, Arvin, Calif. '28
Stolz, H. P., 719 Security Bldg., 510 S. Spring St., Los Angeles, Calif. '28
Stone, Jefferson A., 2220 N. Jordan, Oklahoma City, Okla. '27
Stoner, R. C., Standard Oil Co., Prod. Dept., 225 Bush St., San Francisco, Calif. '21
Storm, Lynn W., 820 Esperson Bldg., Houston, Tex. '25
Storm, Willis, 1730 Milam Bldg., San Antonio, Tex. '20
Strachan, Clarice Bowers, Geological Dept., Gypsy Oil Co., Tulsa, Okla. '31
Strachan, Clyde G., Geological Dept., Gypsy Oil Co., Tulsa, Okla. '29
Stryker, William L., Fredonia, Kan. '25
||Stubbs, John T., 1050 Emerson, Denver, Colo. '26
||Stucky, Zenas E., Box 577, Capitol Hill Sta., Oklahoma City, Okla. '30
Studt, Charles W., Union Gas Corp., Independence, Kan. '20
Stutzer, Otto, Saxony Mining School, Freiberg, Saxony, Germany '25
Suman, John R., 919 Humble Bldg., Houston, Tex. '19
Sundberg, Karl, Wahrendorffsgatan 1, Stockholm, Sweden '29

Sundt, O. F., 1615 Sterling Bldg., Houston, Tex. '29
Sutton, Frederick A., Standard Oil Co., Manuela Pedraza, K-1400, FCCNA, Argentina, S.A. '24
Swigart, T. E., Shell Petr. Corp., Houston, Tex. '20
Swiger, Rual B., Box 1069, Beeville, Tex. '25

||Tabor, Lawrence L., 314 Panoramic Way, Berkeley, Calif. '28
||Taegel, Edwin A., 1501 Galveston St., Laredo, Tex. '31
Taff, Joseph A., Associated Oil Co., 79 New Montgomery St., San Francisco, Calif. '19
Talbott, W. G., 14 W. First, Hutchinson, Kan. '32
||Tallman, Frank P., Box 281, Coudersport, Pa. (Mail returned) '29
Tandy, J. Hiram, Route No. 11, Tulsa, Okla. '26
Tanner, Hugh A., 40 E. Broadway, Winchester, Ky. '27
Tappolet, W., Apartado 130, Tampico, Tamps., Mexico '25
Tarr, W. A., 704 Westwood Ave., Columbia, Mo. '27
||Tarragona, Jose, Yacimientos Petroliferos Fiscales, Division Geologia, Paseo Colon 922, Buenos Aires, Argentina, S. A. '31
||Tatum, Emmett P., Jr., 307 Annex B, 903 Humble Bldg., Houston, Tex. '29
Tatum, James L., Apartado 209, Monterrey, N. L., Mexico '20
Taylor, Charles B., 440 Liberty Natl. Bank Bldg., Oklahoma City, Okla. '17
Taylor, Cyril B., 3624 Watonga Rd., Fort Worth, Tex. '25
Taylor, Dewitt E., 405 Haberfelde Bldg., Bakersfield, Calif. '28
||Taylor, Vernon, 119 Sixth Ave. W., Calgary, Alta., Canada '31
||Taylor, W. Harlan, 315 W. Seventeenth St., Oklahoma City, Okla. '30
||Teagle, John, Humble Oil & Refg. Co., Box 1084, San Antonio, Tex. '31
Teas, L. P., Humble Oil & Refg. Co., Houston, Tex. '21
Teas, Paul C., 2014 W. Magnolia, San Antonio, Tex. '22
||Teis, Maurice R., Phillips Petr. Co., Bartlesville, Okla. '30
Templeton, James Clark, International Geophysical Prosp. Co., Ltd., 10-12 Copthall Ave., London, E.C. 2, England '26
TenEyck, Warren E., 4041 Pacific Ave., Long Beach, Calif. '32
Terrill, John V., Box 1428, Amarillo, Tex. '28
Tester, Allen C., Dept. of Geology, University of Iowa, Iowa City, Iowa '21
||Thacher, John H., Jr., Bin XX, Taft, Calif. '31
Thalmann, Hans E., N. V. de Bataafsche Petr. Mij., Pangkalan Brandan, Sumatra, D. E. I. '27
Thom, W. T., Jr., Dept. of Geology, Princeton University, Princeton, N. J. '22
Thomas, George Dewey, Box 1293, Shreveport, La. '27
Thomas, Harold S., 2841 W. Twenty-First St., Oklahoma City, Okla. '32
Thomas, J. Elmer, 1316 Fort Worth Natl. Bank Bldg., Fort Worth, Tex. '17
||Thomas, Leonard C., Dept. of Geology, University of Iowa, Iowa City, Iowa '30
Thomas, Norman L., Pure Oil Co., Box 2107, Fort Worth, Tex. '26
Thomas, William A., Pure Oil Co., 402 Second Natl. Bank Bldg., Saginaw, Mich. '26
Thompson, A. Beeby, 18 St. Swithins Lane, London, E.C. 4, England '19
Thompson, B. E., Gulf Production Co., Box 1290, Fort Worth, Tex. '24
||Thompson, Edwin I., Box 18—Jordan, Oklahoma City, Okla. '31
Thompson, Evan G., Box 800, Tyler, Tex. '29
Thompson, James D., Jr., Room 3, Amarillo Natl. Bank Bldg., Amarillo, Tex. '23
Thompson, R. R., 1609 Frederick St., Fort Worth, Tex. '20
Thompson, Sheridan A., Magnolia Petr. Co., Box 1406, Shreveport, La. '23
Thompson, Wallace C., General Crude Oil Co., Box 2252, Houston, Tex. '20
||Thompson, William Allen, Route 1, Des Moines, Iowa '31
Thoms, Harold Wayne, Mill City, Nevada '30
Thomson, H. Britton, Pure Oil Co., Box 2107, Fort Worth, Tex. '23
Thornburg, D. H., Newhall, Calif. '23
Thornburgh, H. R., 119 N. Ave. 25, Los Angeles, Calif. '25
Thorne, B. L., Dept. of Natural Resources, Canadian Pacific Rwy., Calgary, Alta., Canada '30
Tickell, Frederick G., 652 Forest Ave., Palo Alto, Calif. '23
Tiedemann, Alex W., c/o B. P. M., Pladjoe, Sumatra, D. E. I. '26
Tieje, Arthur J., Cordova Hotel, Eighth & Figueroa, Los Angeles, Calif. '25
Tillotson, Allen W., 1509 S. Gillette St., Tulsa, Okla. '28
Toler, Henry N., Box 546, Jackson, Miss. '26
Tollefson, E. H., Hope Construction & Refg. Co., Clarksburg, W. Va. '26

Tolmachoff, I. P., Carnegie Museum, Pittsburgh, Pa. '27
Tolwinski, K., Karpachi Instytut Geol.-Naftowy, Service Geologique Karpatique, W. Boryslaw, Poland '31
Tomlinson, Charles W., 509 Simpson Bldg., Ardmore, Okla. '21
Tong, James A., Apartado 330, Maracaibo, Venezuela, S. A. '25
Torrey, Paul, Torrey, Fralich & Simmons, Box 191, Bradford, Pa. '25
Touwaide, Marcel E., Somiba, Angumu, by Stanleyville, Belgian Congo '29
Townley, Enid, 905 S. First St., Champaign, Ill. '33
Townsend, Rex M. F., Room 2907, 120 Broadway, New York, N. Y. '27
Trager, Earl A., Natl. Park Service, Room 4131, Interior Bldg., Washington, D. C. '18
Trask, Parker D., U. S. Geological Survey, Washington, D. C. '26
||Travis, Abe, 110 Mid-Co. Bldg., Tulsa, Okla. '30
Trenchard, John, 314 W. Ridgewood, San Antonio, Tex. '30
Triplett, Richard L., Western Gulf Oil Co., 417 S. Hill St., Los Angeles, Calif. '28
Trowbridge, Arthur C., 1182 E. Court St., Iowa City, Iowa '22
Troxell, John N., The Texas Co., Box 2420, Tulsa, Okla. '25
Truex, Arthur F., 1815 Easton Pl., Tulsa, Okla. '19
Trumpy, D., Sarawak Oilfields, Ltd., Miri, Sarawak '25
Tschopp, H. I., Bataafsche Petr. Mij., 30 Carel van Bylandtlaan, The Hague, Holland '27
Tuchel, Georg, Podbielki Str. 31, Hannover, Germany '27
||Tucker, M. B., 5340 Neosho St., St. Louis, Mo. '26
Tucker, Rietz C., Box 265, Morgantown, W. Va. '21
Turman, Arthur F., 1111 Standard Oil Bldg., San Francisco, Calif. '23
Turner, Joseph H., North Branch Development Co., Wellsboro, Pa. '28
Twenhofel, W. H., Science Hall, University of Wisconsin, Madison, Wis. '20
Tygrett, H. V., Atlantic Oil Prod. Co., Magnolia Bldg., Dallas, Tex. '23
Tyson, Alfred K., 925 Milam Bldg., San Antonio, Tex. '24

Umpleby, Joseph B., City Natl. Bank Bldg., Norman, Okla. '19
||Upp, Jerry E., Conservation & Survey Div., University of Nebraska, 108 Nebraska Hall, Lincoln, Neb. '29
Uren, Lester C., Dept. of Geology, University of California, Berkeley, Calif. '26
Uwatoko, Kunio, Dept. of Geology & Mineralogy, Hokkaido Imperial University, Sapporo, Japan '29
Uyemura, Kimio, No. 42, Honchō-dōri-Gochōme, Nakano-ku, Tokyo, Japan '32

||Valentine, William W., 585 Winthrop Rd., San Marino, Calif. '30
Valerius, Claude N., Jay, Okla. '25
Valerius, M. M., Jay, Okla. '18
||Vallat, Eugene H., 505 Georgina Ave., Santa Monica, Calif. '31
Van Burgh, Lisle R., 616 E. Cypress, Glendale, Calif. '21
Vance, Harold, Box 1505, Kilgore, Tex. '31
Van Couvering, Martin, 704 Wright & Callender Bldg., Los Angeles, Calif. '24
Van Dall, John E., 2837 N. W. Nineteenth St., Oklahoma City, Okla. '22
van der Gracht, W. A. J. M., Staatstoezicht op de Mynen, Maastricht, Holland '17
Vander Leck, Laurence, Box 117, Altadena, Calif. '26
van der Linden, B. H., Wagenaarweg 12, The Hague, Holland '19
Vanderpool, Harold C., 304 S. Peters Ave., Norman, Okla. '26
Van Gilder, H. R., Box 83, Coudersport, Pa. '24
†van Gogh, F. A. A., Zeekant 108, Schev., The Hague, Holland '21
Van Orstrand, C. E., 1607 Thirty-First St. N. W., Washington, D. C. '31
Van Tuyl, Francis M., Colorado School of Mines, Golden, Colo. '22
Van Zant, James H., Box 958, Enid, Okla. '24
||Varley, Wayne, Whitesboro, Tex. '32
Vaudoit, Paul L., 2229 Del Monte Drive, Houston, Tex. '26
Vaughan, F. E., 109 E. Foothill Blvd., Altadena, Calif. '23
Vaughan, T. Wayland, Scripps Inst. of Oceanography, La Jolla, Calif. '26
Veatch, A. C., 170 Broadway, New York, N. Y. '20
Vedder, Dwight G., 811 W. Seventh St., Room 510, Los Angeles, Calif. '29
Vernon, I. J., Coweta, Okla. '25
Vernon, Jess, Amerada Petr. Corp., Drawer 2040, Tulsa, Okla. '25
Vernon, Robert D., Highclere, Plains Rd., Mapperley, Nottingham, England '26

Versluys, Jan, 6 De Lairessestraat, Amsterdam, Holland.......................'28
Vertrees, Charles D., Continental Oil Co., Box 1426, Midland, Tex...............'24
Ver Wiebe, Walter A., Dept. of Geology, University of Wichita, Wichita, Kan....'19
Vetter, John M., Rio Bravo Oil Co., Houston, Tex...............................'24
Vickery, Ward R., 261 S. Delrose St., Wichita, Kan.............................'28
Voitesti, Ion Popescu, Str. Elisabeta 12, Cluj. Roumania.......................'26
von Buelow, E. U., 509 Seventeenth St., Denver, Colo...........................'28
||von Estorff, Fritz E., Hohenstr. 4, Potsdam, Germany...........................'30
||von Zwerger, Rudolf, Teltowerstrasse 17, Berlin-Zehlendorf, Germany...........'30

Wagener, Charles H., 408 Park Ave., Park Hill Estates, San Antonio, Tex........'20
||Waggoner, Stephen Gose, 2013 Brown St., Wichita Falls, Tex.....................'29
Wagner, Carroll M., 1003 Higgins Bldg., Los Angeles, Calif.....................'20
||Wagner, Clyde L., 2259 S. Troost, Tulsa, Okla...................................'27
||Wagner, J. Basil, Box 37, Chandler, Okla.......................................'27
Wahlstrom, Edwin A., Stanolind Oil & Gas Co., Hobbs, N. Mex....................'27
Wails, Elmer D., 518 Exchange Natl. Bank Bldg., Tulsa, Okla....................'31
Waldschmidt, W. A., Colorado School of Mines, Golden, Colo.....................'26
Walker, Lucian H., 326 Beacon Life Bldg., Tulsa, Okla..........................'20
Walker, K. A., 325 W. Sixth St., Bristow, Okla.................................'30
Walker, W. L., 1166 Subway Terminal Bldg., Los Angeles, Calif..................'18
Wall, Earle R., 605 N. Bridge St., Victoria, Tex...............................'29
||Wallis, William E., Cia. de Petroles Mercedes, S. A., Apartado 94, Tampico, Tamps., Mexico...'30
||Walter, Karl L., 1137 Elizabeth St., Denver, Colo...............................'29
||Walters, Mason G., 103 Arnold Ave., Port Allegany, Pa...........................'28
Walters, Ray P., Romano Americana, 126 Calea Victoriei, Bucharest, Roumania..'20
Waltman, W. D., 601 Edison Bldg., Fifth at Grand, Los Angeles, Calif...........'29
||Walton, O. E., Box 817, San Angelo, Tex...'30
Wanemacher, Joseph M., Shell Petr. Corp., Tulsa, Okla..........................'27
Wanless, Harold R., 126 Natural History Bldg., Urbana, Ill.....................'32
Wantland, Dart, 600 Fourteenth St., Golden, Colo...............................'31
Ward, Freeman, Lafayette College, Easton, Pa...................................'30
Waring, Gerald A., 708 E. Seneca St., Ithaca, N. Y.............................'23
Waring, W. W., Geological Dept., Tropical Oil Co., Barranca-Bermeja, Colombia, S. A...'29
Warner, Charles A., Box 2412, Houston, Tex.....................................'19
Warner, J. Laird, Route 1, Box 99, McAllen, Tex................................'30
||Warner, Ralph E., Y. M. C. A., Bradford, Pa.....................................'31
||Warthin, Aldred S., Jr., Dept. of Geology, Vassar College, Poughkeepsie, N. Y.'28
Washburne, Chester W., 149 Broadway, New York, N. Y............................'18
Wasson, Harold J., 25 Broadway, New York, N. Y.................................'27
Wasson, Isabel B., 606 Thatcher, River Forest, Ill.............................'27
Wasson, Theron, Room 2308, 35 E. Wacker Drive, Chicago, Ill....................'20
Waterfall, Louis N., Union Oil Co. of California, 1114 Union Oil Bldg., Los Angeles, Calif...'24
Waters, James A., Box 2880, Dallas, Tex..'25
Watkins, William A., Standard Oil Co. S. A. Arg., Plaza Huincul F. C. Sud., Argentina, S. A...'23
Watson, C. P., Room 970, 417 S. Hill St., Los Angeles, Calif...................'25
Watson, Joseph D., Turman Oil Co., 518 Exchange Bank Bldg., Tulsa, Okla........'21
Weatherby, B. B., 1123 E. Twenty-Fifth St., Tulsa, Okla........................'30
Weatherston, Douglas, 203 E. Ragland St., Kingsville, Tex......................'30
Weaver, George A., 759 Ratcliff, Shreveport, La................................'26
Weaver, Paul, Drawer 2100, Houston, Tex..'20
||Webb, James A., 902 San Pedro, San Antonio, Tex.................................'30
||Weddle, Herman W., Box 1390, Station C, Los Angeles, Calif......................'29
||Wedel, Arthur, Box 812, Crockett, Tex...'32
||Weed, William F., Box 660, Beaumont, Tex..'26
Weeks, Albert W., Exploration Dept., Shell Petr. Corp., Houston, Tex...........'27
Weeks, Herbert J., Sun Oil Co., 1608 Walnut St., Philadelphia, Pa..............'24
Weeks, Lewis G., Standard Oil Co., Compamento Central, Manuela Pedraza, FCCNA, Salta Argentina, S. A...'24

||Weeks, Warren B., Geological Dept., Phillips Petr. Co., Bartlesville, Okla..........'29
Wegemann, Carroll H., Crown Central Petr. Corp., Box 1759, Houston, Tex.........'20
||Weidmann, Carl, bei Herrn Otto Wertheimber de Bary, Hacienda Canana, para Senor Fernando Emmel, Cuzco, Peru, S. A..........'31
||Weintz, Clement A., 1021 Lincoln Ave., Loveland, Colo..........'27
Weinzierl, John F., 607-8 Petroleum Bldg., Houston, Tex..........'22
Weisbord, Norman E., 227 Haven Ave., New York, N. Y..........'25
||Welch, Virgil H., 1809 N. Park, Shawnee, Okla..........'27
||Weller, J. Marvin, State Geological Survey, Urbana, Ill..........'29
Wellings, F. E., Iraq Petr. Co. Ltd., Box 309, Haifa, Palestine..........'24
Wells, Samuel W., Box 1266, Okmulgee, Okla..........'19
Wender, W. G., Box 1058, Cisco, Tex..........'26
Wendlandt, E. A., Humble Oil & Refg. Co., Box 598, Tyler, Tex..........'24
Westby, Gerald H., Seismograph Service Corp., 709 Kennedy Bldg., Tulsa, Okla....'23
||Westheimer, Jerome M., 401 I St., S. W., Ardmore, Okla..........'32
||Wethington, William O., Nash, Okla..........'30
Weymouth, A. Allen, Bahrein Petr. Co. Ltd., Bahrein Island, Persian Gulf..........'29
||Wharton, H. Jerome, Apartado 234, Maracaibo, Venezuela, S. A..........'28
Wheeler, H. A., Security Bldg., St. Louis, Mo..........'27
Wheeler, James D., Box 517, Henderson, Tex..........'29
Wheeler, Orby Clinton, International Petr. Co., 56 Church St., Toronto, 2, Ont., Canada..........'26
Whisenant, J. Barney, 206 E. Lullwood, San Antonio, Tex..........'25
||White, Gordon H., 613 Shell Bldg., 1008 W. Sixth St., Los Angeles, Calif..........'29
White, Kessack D., Caixa Postal 3532, Sao Paulo, Brazil, S. A..........'22
White, Luther H., 211 E. Jasper St., Tulsa, Okla..........'20
*White, David, U. S. Geological Survey, Washington, D. C..........'19
White, Maynard P., Gypsy Oil Co., Box 30, Ardmore, Okla..........'25
White, Roger F., Bank of America Bldg., Los Angeles, Calif..........'23
White, Stanley B., Box 981, Tulsa, Okla..........'24
Whitehead, R. Brooks, 806 Magnolia Bldg., Dallas, Tex..........'19
Whitehead, W. L., 222 Charles River Rd., Cambridge, Mass..........'29
Whiteside, Robert M., Box 1191, Tulsa, Okla..........'28
Whitney, F. L., University Station, Austin, Tex..........'20
Whittier, William H., Box 1299, Albuquerque, N. Mex..........'24
Whitwell, E. V., 1344 Terrace Drive, Tulsa, Okla..........'19
Whorton, Chester D., Box 83, Coudersport, Pa..........'29
Wiedenmayer, Carl, Standard Oil Co. of Venezuela, Apartado 85, Maracaibo, Venezuela, S. A..........'26
Wiest, Frank C., 403-404 Springer Bldg., Tulsa, Okla..........'21
Wilcox, Fred H., 15 Charleston St., Wellsboro, Pa..........'29
Wilde, Henry Dayton, Humble Oil & Refg. Co., Houston, Tex..........'33
||Wilhelm, Arthur K., 407 W-K-H Bldg., Wichita, Kan..........'28
Williams, Francis S., W. C. McBride, Inc., Box 117, McPherson, Kan..........'24
||Williams, G. Allen, Livingston, Tex..........'27
||Williams, George C., 1843 W. Forty-Seventh St., Los Angeles, Calif..........'27
Williams, George O., 2805 W. Twentieth St., Oklahoma City, Okla..........'27
Williams, Herbert E., 1314 Second Natl. Bank Bldg., Houston, Tex..........'26
Williams, Ira A., 821 Spalding Bldg., Portland, Ore..........'31
||Williams, Lenora May, Drawer 2040, Tulsa, Okla..........'31
||Williams, Thomas Harold, Buffalo, Okla..........'32
Williams, W. A., 2518 Prospect St., Houston, Tex..........'19
Williamson, Thomas F., Victoria Cottage, Pittenweem Fife, Scotland..........'32
Willis, Cornelius G., 409 A. G. Bartlett Bldg., Los Angeles, Calif..........'25
Willis, Robin, Nordon Corp., Lougheed Bldg., Calgary, Alta., Canada..........'27
Willis, S. Morse, 510 N. Kentucky, Roswell, N. Mex..........'24
Williston, Samuel H., Roosevelt Apts., Aberdeen, Wash..........'24
Willson, Kenneth M., 3837 Bunting St., Fort Worth, Tex..........'29
Wilson, Edward B., Sun Oil Co., San Antonio, Tex..........'22
||Wilson, Homer M., Box 250, Marathon, Tex..........'27
Wilson, John H., Box 187, Golden, Colo..........'21
Wilson, Joseph G., 203 S. Willomott, Dallas, Tex..........'31
Wilson, Joseph M., Simms Oil Co., 10th Floor Magnolia Bldg., Dallas, Tex.......'22

Wilson, Malcolm E., 104 E. Grove St., El Dorado, Ark. '20
Wilson, Robert R., Box K-1, Beverly Hills, Calif. '30
||Wilson, Thomas C., Colombia Petr. Co., Apartado 100, Cucuta, Colombia, S. A. '30
Wilson, Walter B., Gypsy Oil Co., Box 661, Tulsa, Okla. '21
||Wimbish, Forrest E., 832 N. Delrose, Wichita, Kan. '28
Wines, Donald Bradford, 303 Creek, Bartlesville, Okla. '29
||Winkler, Hans, 104 W. Thirty-Second St., Austin, Tex. '31
Winn, W. E., 3240 Daniel St., Dallas, Tex. '31
Winston, W. Bruce, 208—I. N. Van Nuys Bldg., Los Angeles, Calif. '31
Winter, Niles B., Box 949, San Angelo, Tex '24
||Winterer, Edward V., 2620 San Emidio St., Bakersfield, Calif. '27
Winton, Will M., Texas Christian University, Fort Worth, Tex. '20
Wissler, Stanley G., Union Oil Co. of Calif., Box F, Compton, Calif. '27
Wolf, Albert G., Texas Gulf Sulphur Co., 1009 Second Natl. Bank Bldg., Houston, Tex. '24
Wolff, Deane J., 1339 Keeler St., Bartlesville, Okla. '23
||Wolters, Earl M., Humble Oil Co., Drawer D, Houston, Tex. '30
Wood, Douglas, British Controlled Oilfields, Ltd., Apartado 232, Maracaibo, Venezuela, S. A. '33
Wood, Fred E., Standard Oil Co. of Indiana, 910 S. Michigan Ave., Chicago, Ill. '24
||Wood, George R., 519 N. Franklin St., Hampton, Iowa '30
Wood, James T., Jr., 365 S. El Molino, Pasadena, Calif. '24
||Wood, J. Pendleton, 341 Marion St., Denver, Colo. '27
Wood, Robert H., 430 Beacon Life Bldg., Tulsa, Okla. '20
Wood, Virgil O., 430 Beacon Life Bldg., Tulsa, Okla. '20
Woodford, Alfred O., Pomona College, Claremont, Calif. '24
Woods, E. Hazen, Superior Oil Co., Box 1106, Midland, Tex. '25
||Woods, Percy O., Humphreys Corp., Mt. Belvieu, Tex. '31
Woods, Sam H., Twin State Oil Co., Box 1348, Tulsa, Okla. '25
||Woodward, George E., Box 2332, Houston, Tex. '29
Woodward, Harold Robinson, Box 31, Wichita, Kan. '25
Woolley, Glen C., 1812 Parker St., Wichita, Kan. '28
Woolnough, W. G., Dept. of Home Affairs, Canberra, F. C. T., Australia '29
Woolsey, E. V., Box 360, Luling, Tex. '20
Wosk, L. David, 507 Commonwealth Bldg., San Diego, Calif. '24
Wrather, W. E., 4300 Overhill Drive, Dallas, Tex. '17
Wright, Andrew C., Box 295, Rockdale, Tex. '20
Wright, A. P., 918 McBirney Bldg., Tulsa, Okla. '22
Wright, Fay Linton, 6416 Lindenhurst Ave., Los Angeles, Calif. '27
Wright, Fred S., Box 24, Midland, Tex. '20
Wright, Harry F., 510 Commercial Bldg., Tulsa, Okla. '19
Wright, Hugh, 1008 Second Natl. Bank Bldg., Houston, Tex. '30
Wylie, James R., Jr., 2811 Grant Bldg., Pittsburgh, Pa. '21
Wyllie, B. K. N., Anglo-Persian Oil Co., Britannic House, Finsbury Circus, London, E.C. 2, England '27
Wyman, Everett A., Box 995, Wichita, Kan. '24
Wynn, Warren H., Box 859, Shawnee, Okla. '26

Yager, Charles E., Box 2110, Fort Worth, Tex. '24
Yeager, Lloyd I., 407 W-K-H Bldg., Wichita, Kan. '30
Yewell, P. R., Box 504, Stanford University, Calif. '26
Yoakam, Coler A., Box 1162, Oklahoma City, Okla. '22
Young, Addison, General Delivery, Rio Grande City, Tex. '30
||Young, Claude T., 410 S. Church St., Cordell, Okla. '27
Young, Jackson S., Box 1349, Monroe, La. '28
Young, Karl E., 713 Esperson Bldg., Houston, Tex. '26
Young, Umberto, Pacific Finance Bldg., Los Angeles, Calif. '28
||Youngmeyer, Ray, Box 707, Chickasha, Okla. '27
Youngs, L. J., 612 Orpheum Bldg., Wichita, Kan. '20
Younkman, Harry, 522-A W. Brady St., Tulsa, Okla. '21

Zaba, Joseph, Rio Bravo Oil Co., Houston, Tex. '33
Ziebold, William O., 1572 Virginia St., Charleston, W. Va. '29

‖Zimerman, Sam, Humble Oil & Refg. Co., Box 544, Guthrie, Okla. . . . . '31
Zimmerman, C. C., The Texas Co., Box 2332, Houston, Tex. . . . . '31
Zimmerman, James Z., 511 Union Natl. Bank Bldg., Wichita, Kan. . . . . '22
Zoller, H. E., Shell Petr. Corp., Box 1191, Tulsa, Okla. . . . . '25
Zoller, Lawrence J., Box 2306, Tulsa, Okla. . . . . '21
Zorichak, Joseph J., Stanolind Oil & Gas Co., Philcade Bldg., Tulsa. Okla. . . . . '24
Zuber, Stanislav, Hotel Boston, Rome, Italy . . . . '31

ASSOCIATION COMMITTEES

EXECUTIVE COMMITTEE

FRANK R. CLARK, *chairman*, Mid-Kansas Oil and Gas Company, Tulsa, Oklahoma
WILLIAM B. HEROY, *secretary*, Consolidated Oil Corporation, New York, N. Y.
FREDERIC H. LAHEE, Sun Oil Company, Dallas, Texas
GEORGE SAWTELLE, Kirby Petroleum Company, Houston, Texas
L. C. SNIDER, H. L. Doherty and Company, New York, N. Y.

GENERAL BUSINESS COMMITTEE

RUSSELL S. KNAPPEN (1934), *chairman*, Gypsy Oil Company, Box 661, Tulsa, Oklahoma
ED. W. OWEN (1934), *vice-chairman*, 1015 Milam Building, San Antonio, Texas

ARTHUR A. BAKER (1934)	WILLIAM B. HEROY (1934)	L. W. ORYNSKI (1934)
ALBERT L. BEEKLY (1934)	JOHN F. HOSTERMAN (1935)	CLARENCE F. OSBORNE (1935)
FRANK R. CLARK (1935)	EDGAR KRAUS (1935)	E. E. ROSAIRE (1934)
H. E. CRUM (1935)	FREDERIC H. LAHEE (1934)	GEORGE SAWTELLE (1934)
C. L. DAKE (1935)	ROLAND W. LAUGHLIN (1935)	GAYLE SCOTT (1934)
JOSEPH A. DAWSON (1935)	THEODORE A. LINK (1935)	L. C. SNIDER (1934)
C. E. DOBBIN (1935)	R. T. LYONS (1935)	J. D. THOMPSON (1934)
JAMES TERRY DUCE (1935)	ROY G. MEAD (1935)	WALLACE C. THOMPSON (1935)
WALTER A. ENGLISH (1934)	R. C. MOORE (1934)	PAUL WEAVER (1935)
H. B. FUQUA (1935)	A. F. MORRIS (1935)	G. H. WESTBY (1934)
M. W. GRIMM (1935)	WILLIAM M. NICHOLLS (1934)	E. A. WYMAN (1935)
S. A. GROGAN (1935)	PHILIP E. NOLAN (1935)	

RESEARCH COMMITTEE

DONALD C. BARTON (1936), *chairman*, Humble Oil and Refining Company, Houston, Texas
M. G. CHENEY (1934), *vice-chairman*, Coleman, Texas

K. C HEALD (1934)	C. E. DOBBIN (1935)	L. C. UREN (1935)
F. H. LAHEE (1934)	A. I. LEVORSEN (1935)	HAROLD W. HOOTS (1936)
H. A. LEY (1934)	ALEX. W. MCCOY (1935)	R. S. KNAPPEN (1936)
R. C. MOORE (1934)	C. V. MILLIKAN (1935)	W. C. SPOONER (1936)
F. B. PLUMMER (1934)	L. C. SNIDER (1935)	PARKER D. TRASK (1936)

REPRESENTATIVE ON DIVISION OF GEOLOGY AND GEOGRAPHY NATIONAL RESEARCH COUNCIL

R. S. KNAPPEN (1934)

GEOLOGIC NAMES AND CORRELATIONS COMMITTEE

M. G. CHENEY, *chairman*, Coleman, Texas

JOHN G. BARTRAM	B. F. HAKE	C. L. MOODY
IRA H. CRAM	G. D. HANNA	R. C. MOORE
ALEXANDER DEUSSEN	A. I. LEVORSEN	ED. W. OWEN

TRUSTEES OF REVOLVING PUBLICATION FUND

E. DEGOLYER (1934)	FRANK R. CLARK (1935)	CHARLES H. ROW (1936)

TRUSTEES OF RESEARCH FUND

W . E. WRATHER (1934)	ALEX. W. MCCOY (1935)	ROBERT H. DOTT (1936)

FINANCE COMMITTEE

E. DEGOLYER (1934)	W. E. WRATHER (1935)	JOSEPH E. POGUE (1936)

COMMITTEE ON APPLICATIONS OF GEOLOGY

F. H. LAHEE, *chairman*, Box 2880, Dallas, Texas

WILLIAM H. ATKINSON	HAL P. BYBEE	S. E. SLIPPER
DONALD C. BARTON	W. F. CHISHOLM	E. K. SOPER
FORD BRADISH	HERSCHEL H. COOPER	LUTHER H. WHITE
ARTHUR E. BRAINERD	CAREY CRONEIS	R. B. WHITEHEAD
H. A. BUEHLER	MARVIN LEE	

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 18, NO. 3 (MARCH, 1934), PP. 428-431

Memorial

EPHRAIM NOBLE LOWE

In the passing of Ephraim Noble Lowe, the University of Mississippi lost a teacher; the community, a friend; the Geological Survey, a director; Mississippi, a citizen; Pennsylvania, a wanderer; the Quakers, a son; the South, a gentleman; the North, a grandson; Nature, a nobleman—though Heaven gained a soul. Genial, gentle, generous, he was ever the delight of his friends. It is said of him that he belonged to the Old School; rather, he belonged to the Rare School, the one whose members are so few.

His work can never be dissociated from the man. In fact, his greatest work was the development of the man, the gentleman, the life—the gentle, quiet life that left its benevolent influence on student and colleague, on all who came in contact with it. His next greatest work, perhaps, was the directorate of the State Geological Survey from 1909 to his death in 1933, for truly none other than a genial, gentle, generous soul could have kept courageously on to the end on such pitiful appropriational support. Of the quarter of a century, he writes, that "Except for the years 1920–1921, the Geological Survey has always been handicapped by inadequate financial support."[1]

Notwithstanding these meager appropriations, he was able, as director, to issue 17 bulletins (including two on Forestry and one on Plants), a special report on Archeology, and, in coöperation with the United States Geological Survey, a report on the Ground Water Resources. He directed, in addition, the publication of a number of shorter papers, press reports, and administrative reports—two of the last including (1) a History of the Survey and (2) Petroleum Possibilities. Besides all of these reports, he was able to issue, in coöperation with the United States Department of Agriculture, 40 detailed county soil reports and maps, and, in coöperation with the United States Geological Survey, 30 odd topographic sheets or advanced proofs thereof. In a few instances, however, some of these reports were possible only because of his fine enlistment of coöperation of others—one report being based entirely on a private survey costing thousands of dollars, and another, partly on the laboratory identification of material studied in a great eastern school of technology. These are the visible fruits of his directorship. Less conspicuous but no less real, were his untiring efforts to stimulate within the state the utilization and conservation of the soil resources, the development of the oil and gas industry, the hydro-electric potentialities, the clay industry, and others.

Like so many of the earliest geologists and paleontologists, Dr. Lowe was trained in the School of Medicine. Accordingly, he belongs to that fine school of naturalists manifest by the variety of his efforts and by the range of his publications. While lack of space prohibits the listing of the 30 or more titles of his published reports, a few of the more important should be mentioned. His "Geology, Geography, Soils, and Mineral Resources of Mississippi," first

[1] *National Research Council Bull. 88* (1932), p. 62.

published as *Bulletin 12* (1915), and later revised as *Bulletin 14* (1919), and finally as *Bulletin 20* (1925), is an excellent summation of all existing geologic knowledge of the state at the time of the respective editions. His "Plants of Mississippi," published as *Bulletin 17* (1921), reveals the breadth of his interest and perhaps his most pretentious effort. His contribution to the Coastal Plain stratigraphy of Mississippi in the form of a report on the Midway and Wilcox, which appeared as *Bulletin 25* the year of his death (1933) is, perhaps, his most scientific work. His Biblical story, *The Tishbite*, published by The Stratford Company of Boston (1923), manifests his literary skill.

Ephraim Noble Lowe was born near Utica, Hinds County, Mississippi, May 5, 1864, the son of Edmund F. Lowe (1823–1902), the son of Daniel Lowe (1800–1845), the son of Daniel Lowe (——, —— Mississippi, ——), the son of John Lowe (North Carolina, 1726—Georgia, 1800), a soldier in the War of Independence. John Lowe was, according to the record furnished, a descendant of the Quakers under Penn in Pennsylvania, a branch of the Quakers from Plymouth, Massachusetts, a branch of the Quakers from England. Thence the name seems to extend to Belgium (as Lewes) and to Germany (as Löwe). Ephraim's mother, Emily Minerva Peyton (1833–1873), the second wife of his father, was a descendant of the Peytons, also of England.

Ephraim entered the University of Mississippi in 1879, and was graduated in 1884 as a Bachelor of Philosophy. He was a member of the Sigma Chi fraternity. He pursued one year of post-graduate work in geology and biology *in absentia* during 1889. He attended Tulane University, which granted him the degree of Doctor of Medicine in 1892.

He engaged in private geologic and biologic work in Colorado from 1887 to 1889, and practiced medicine in Mississippi from 1892 to 1893. In 1893 he returned to Colorado, where he remained until 1902, practicing medicine and indulging his biologic and geologic yearnings. Save for a vivid little Christmas story of duty and a dangerous mountain pass, little is recorded of this period of his life, but, no doubt, his soul was attuned to Nature as he roamed the wide expanses of the Rockies from Mexico to Montana, for he dearly loved God's great outdoors. In 1902, he returned to Mississippi on the occasion of the death of his father.

In 1904, he was appointed assistant in biology and geology at the University of Mississippi, serving as such from 1904 to 1906 and attending the University of Chicago during the summers of 1904, 1905, and 1906. He then became acting professor of geology from 1906 to 1908, and professor of geology and assistant State geologist from 1908 to 1909. He next served as director of the Mississippi Geological Survey at Jackson from 1909 to 1924, when the Survey was returned to the University. From 1924 he served as both director and professor of geology until his death on September 12, 1933.

Dr. Lowe was active in a number of scientific societies, civic organizations, and the church. He was a member of the Association of American State Geologists, The American Association of Petroleum Geologists, the Torrey Botanical Club, the National Drainage Congress (State vice-president, 1922), the Southern Water Power Association, the Southern Forestry Congress, the American Association of Soil Survey Workers, the National Economic League, the American Geographical Society, the American Association for the Advancement of Science, the Rotary Club, the Knights of Pythias, and the Methodist Episcopal Church, South.

On November 28, 1895, Dr. Lowe married Sarah M. Yeager of Wauseon, Ohio. To this union two children, Marguerite Emily (Mrs. Paul Warren Bucks), and Edmund Peyton, were born. Mrs. Lowe died on March 21, 1898. On May 14, 1903, Dr. Lowe married Laura Edna Haley of Utica, Mississippi, to whom was born a daughter, Edna May, now deceased. He is survived by Mrs. Lowe and the two children. The body was laid to rest in Old Bear Creek Cemetery, near Utica, the home of the Lowes for several generations.

As in the beginning, so in the end: the World is poorer in the passing of a man; Heaven is richer in the gaining of a soul.

WILLIAM CLIFFORD MORSE

STATE COLLEGE, MISSISSIPPI
January 12, 1934

JAMES EARL HOOVER

Mr. Hoover's early educational training was had in North Carolina, his native state. After graduating from high school in his home town of High Point, he entered the University of North Carolina, where he became interested in geology under the teaching of Dr. Collier Cobb; however, he completed his work for bachelor's degree in the University of New Mexico, where he was graduated in geology with highest honors, in 1918. His honorary fraternity at New Mexico was Phi Kappa Phi (the equivalent of Phi Beta Kappa and Sigma Xi in larger universities); his social fraternity there was Pi Kappa Alpha, of which he was state secretary for Oklahoma after graduation.

Hoover's early field experience in geology was with the Empire and the Gypsy oil companies, in 1917 and 1918. His membership in The American Association of Petroleum Geologists dates from 1919, and he was a charter member of the Tulsa Geological Society. About 1921 he spent a year on the geologic staff of Agwi Petroleum Company, Tampico, Mexico. During several years he and the writer were connected in a partnership as consulting geologists with offices in Tulsa, Oklahoma City, and Fort Worth. In 1926 Hoover joined the Bryan Petroleum Company, of Tulsa, as geologist, and was later a stockholder and officer until his death. His tireless energy as geologist was directed almost altogether along economic lines, wherein he was unusually successful, as is attested by the dozen producing leases secured and developed through his approval and assistance and now owned by that sound and aggressive company.

Following is a more personal review of Jimmy's busy life. He was born of William Albert and Della A. (Millikan) Hoover, at High Point, near Greensboro, North Carolina, July 27, 1894. Left fatherless at a very early age, young James had to thank an elder brother for much help and guidance, and was obliged to manage his higher education largely "on his own." This he did with evidently commendable success, his talents being of practical as well as of academic excellence.

On January 22, 1922, he married Miss Irma Holbert, of Tulsa. Three children were born to the union: an infant son, James Kirk Hoover, died in 1923; two daughters, Frances Elizabeth and Mary Helen, aged 10 and 8 years, respectively, are left with their mother. Jimmy's elder brother, already mentioned, also survives.

The deceased was a Mason and an Elk. Besides ascending the scale of Masonry to the 32d degree he had served his home lodge in all its chairs, being its Master in 1932. Thus in lodge work, as elsewhere, he always strove for the top; yet he was ever helpful and uplifting toward a worthy brother, and was therefore buried with high Masonic honors. Jimmy's other side lines were hunting (he was a crack shot), golf, tennis, and bridge. He was a member of Cedar Crest Country Club and of the Totem Club—past president of the latter.

A combination of winsome personality, genial friendship, vigorous energy, sterling integrity, and capable management had won him singular success at an early age; and his many lovable characteristics had so constantly endeared him to family and friends as to render his life lines indelible in the memory of all of us.

He died at his home in Tulsa, on January 25, 1934, of pneumonia complicated by heart trouble, after an illness of 5 days. An untimely death; yet he somehow crowded a complete lifetime into less than 40 years.

CHARLES T. KIRK

TULSA, OKLAHOMA
February 5, 1934

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 18, NO. 3 (MARCH, 1934), PP. 432-434

AT HOME AND ABROAD

CURRENT NEWS AND PERSONAL ITEMS OF THE PROFESSION

SPECIAL SLEEPERS TO DALLAS

For the convenience of Association members in the north and east who will attend the nineteenth annual meeting in Dallas, March 22–24, the Missouri-Kansas-Texas Railroad will operate special through sleepers for members of the Association from St. Louis to Dallas, attached to their crack trains which also have new air-conditioned dining cars and sun-parlor lounge cars with radio. Members can make reservations through their nearest M-K-T representative, or through the representative of the railroad serving their home city. Members attending from Kansas City and Tulsa will be on the same train upon arrival in Dallas.

Lv. St. Louis	M-K-T	"Texas Special"	6:30 P.M.	March	20
Lv. Kansas City			10:10 P.M.		20
Ar. Dallas			12:15 P.M.		21
Lv. St. Louis	M-K-T	"Bluebonnet"	1:40 P.M.	March	21
Lv. Kansas City			4:35 P.M.		21
Lv. Tulsa			10:00 P.M.		21
Ar. Dallas			7:45 A.M.		22
Lv. St. Louis	M-K-T	"Texas Special"	6:30 P.M.	March	21
Lv. Kansas City			10:10 P.M.		21
Ar. Dallas			12:15 P.M.		22

The Ninth International Congress of Pure and Applied Chemistry will be held on April 5–11, 1934, at Madrid. Detailed information may be obtained by addressing the general secretary, Apartado 8043, Madrid (8), Spain.

The Eastern District meeting of the Division of Production of the American Petroleum Institute will be held at State College, Pennsylvania, April 6 and 7, according to the announcement of J. J. MONTGOMERY, JR., of the United Natural Gas Company, Oil City, Pennsylvania, chairman of the Eastern District. This year's Petroleum and Natural Gas Conference of the Pennsylvania State College Mineral Industries Division is being dispensed with to allow the American Petroleum Institute to hold its meeting there.

In January, Professor J. HARLAN JOHNSON, of the Colorado School of Mines, Golden, was elected a vice-president of the Geological Society of France.

At a meeting of the Tulsa Geological Society, February 5, G. H. WESTBY, vice-president of the Seismograph Service Corporation, spoke on "Problems in Reflection Seismology."

C. W. SHANNON, former head of the Oklahoma Geological Survey, and more recently Cleveland County relief supervisor, died February 1, at his home at Norman, Oklahoma, at the age of 55.

J. B. DRAGUSANU, formerly with the Columbia Gas and Electric Corporation, Pittsburgh, Pennsylvania, is now at 25, Rue Saussure, Paris, 17, France.

H. F. SMILEY has resigned his position as geologist for the Deep Oil Development Company, at Wichita Falls, Texas, and is operating independently.

THOMAS C. WILSON has changed his address from the Venezuela Gulf Oil Company, Maracaibo, Venezuela, to the Colombian Petroleum Company, Apartado 100, Cucuta, Colombia, S. A.

EVERETT C. PARKER, formerly of Alice, Texas, may be addressed at 319 S. Carancahua, Corpus Christi, Texas.

WILBUR H. SEIFERT, formerly with St. Marys Natural Gas Company, St. Marys, Pennsylvania, is now with the United Natural Gas Company in the Millstone field. His address is R. F. D., Hallton, Pennsylvania.

THORNTON DAVIS, in the geological department of the Simms Oil Company, San Antonio, Texas, was recently elected president of the San Antonio Petroleum Club.

J. BRIAN EBY, geologist and geophysicist of Houston, Texas, spoke before the Houston Geological Society, February 1, on the "North German Salt Dome Basin."

E. H. SELLARDS, director of the Bureau of Economic Geology, University of Texas, Austin, is to administer a $3,000 grant from the Penrose Fund of the Geological Society of America, intended for a group study to establish more satisfactory criteria for the stratigraphic correlation of the Mississippian, Pennsylvanian, and Permian sediments in Texas. It will require the work of four members of the Bureau of Economic Geology and all of 1934 to complete.

GEORGE C. MCGHEE, of the geophysical department of the Continental Oil Company, at Victoria, Texas, was recently selected as the Rhodes scholar from his district.

C. A. WARNER, formerly assistant chief geologist of the Houston Oil Company, Houston, Texas, has been made superintendent of the newly formed separate land department of that company. PHILLIP F. MARTYN continues as head of the geological department.

JAMES E. HOOVER, secretary-treasurer and geologist for the Bryan Petroleum Company, Tulsa, Oklahoma, died January 25, at the age of 38.

COE S. MILLS has recently been engaged as geologist for Pugh-Hickman Drilling Company, Shreveport, Louisiana.

BURR MCWHIRT was recently employed by the Shell Petroleum Corporation for geological work. His headquarters are at Houston, Texas.

Wallace C. Thompson, formerly district geologist for the Sun Oil Company, Tyler, Texas, has been transferred to Houston and promoted to the position of chief geologist for the General Crude Oil Company. Both companies are controlled by the Pew estate, the latter, which was formerly known as the Cranfill-Reynolds Company, having recently been purchased by them.

M. G. Cheney, president of the Anzac Oil Corporation, Coleman, Texas, was the principal speaker at the monthly meeting of the West Texas Geological Society in San Angelo, Texas, February 3. His paper was on "The Concho Arch."

Robert Brown, geologist with the Amerada Petroleum Corporation, formerly located at Shawnee, Oklahoma, has been transferred to the Houston, Texas, office of the company.

Donald C. Barton has closed his consulting office in Houston, Texas, and accepted a position as consulting and research geologist for the Humble Oil and Refining Company.

A. Irving Levorsen has been made chief geologist of the Tide Water Oil Company of Oklahoma, and will be located at Houston, Texas.

A. W. Lauer has resigned his position as division geologist of the Oklahoma-Kansas-Kentucky division of The Texas Company, effective March 1, to pursue certain researches in geology.

Shelley Krasnow, manufacturer of scientific instruments, 817 G Street, N. W., Washington, D. C., has been licensed by the Carnegie Institution of Washington to build the Gish-Rooney earth resistivity apparatus and is prepared to furnish it to anyone interested.

W. C. Spooner, consulting geologist of Shreveport, Louisiana, has moved his office to the Atlas Building, Shreveport. His mail address is Box 1195.

W. F. Chisholm, district superintendent in Louisiana and Arkansas for the Halliburton Oil Well Cementing Company, is severing his connections with that firm, effective April 1. His address is 2511 Highland Avenue, Shreveport, Louisiana.